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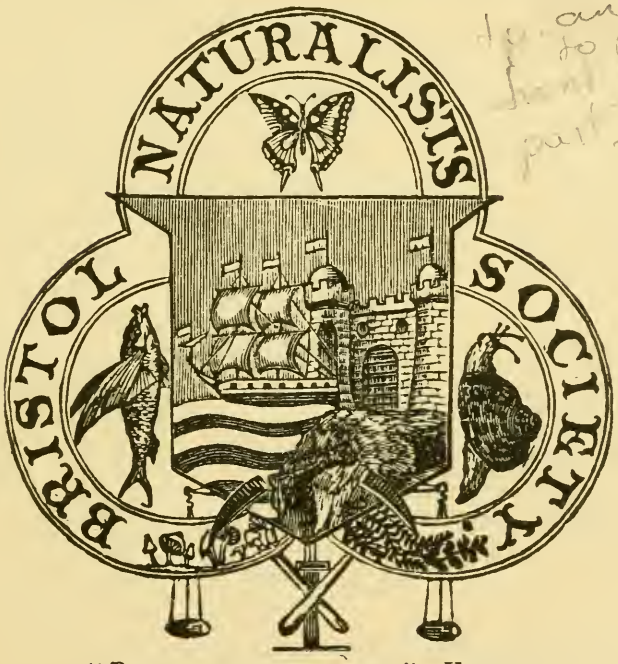

"*Rerum cognoscere causas.*"—VIRGIL.

BRISTOL: JAMES FAWN & SON.

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Henry Edward Fripp,

M.D., M.R.C.P.

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DR. FRIPP, a worthy successor to Mr. Sanders in the presidential chair of the Bristol Naturalists' Society, was born in 1816, and passed through his curriculum at the Bristol Medical School, being a pupil of the late Dr. Symonds, at the Bristol General Hospital. In 1838 he became a member of the Royal College of Surgeons, and then began practice in Wales as medical officer to the iron works at Yniscedwyn, near Swansea. Shortly after this he went to Germany as medical officer to the iron works at Nisterthal, in the Duchy of Nassau. Having by nature an aptitute for mechanics, Dr. Fripp took so great an interest in these works, that, in addition to his professional responsibilities, at the request of the directors, he accepted the office of chief engineer, and held this post till 1848, when these works were closed owing to disturbances consequent upon the unsettled state of the political atmosphere. After this Dr. Fripp spent some years on the Continent in medical and scientific study and research, and in 1855 took the degree of M.D. at Würtzburg. While abroad he worked for some considerable time under Kölliker. In 1856 he obtained the membership of the Royal College of Physicians of London, and settled in Clifton as a physician. He was soon elected physician to the Bristol General Hospital, and held this

post till 1873, when he was made consulting physician to that institution. He occupied the chair of physiology in the Bristol Medical School from 1857 to 1869.

Dr. Fripp, as one of the seven members of the Provisional Committee, was one of the founders of the Bristol Naturalists' Society. In its welfare he always manifested the greatest interest, and took a leading part in its proceedings, as will be seen by the accompanying list of the papers he at various times delivered at the general meetings.

Nov. 3rd, 1864. "Notes on the Glow-worm." (An elaborate paper.)

April 6th, 1865. Introductory paper "On the Structure of the Eye in the Cephalopod Mollusca."

Jan. 4th, 1866. "On the Vision of Fish and on Certain Structural Peculiarities of the Fish's Eye."

Jan. 3rd, 1867. "Recent Discoveries in Insect Embryology."

Feb. 6th, 1868. "The Anatomy of the Retina and the Physiology of Vision."

May 13th, 1869. "A Notice of Recent Observations on Amœbæ and Monads by Richard Greef and L. Cienkowski."

Jan. 4th, 1872. "On Animal Sensation, and the Sense of Touch in Bat and Fish, and the Organ of Hearing in Snails."

Feb. 4th, 1875. "A Chapter on the Choice of a Microscope."

March 2nd, 1876, and March 1st, 1877. "On Insect Anatomy."

Jan. 3rd, 1878. "On Insect Sounds."

Dec. 5th, 1878. "On the Faculty of Hearing, and on the Tympanal Organ of certain Orthoptera."

Besides these the following important papers of his were published in the Society's Proceedings:—

"On the Physiological Limits of Microscopic Vision."

"Preface to Dr. Abbe on the Microscope."

"On Aperture, and Definition of the Microscope Object-Glass."

"On the Limits of the Optical Capacity of the Microscope." Translated from Helmholtz.

"On Prof. Abbe's Method of Testing the Optical Quality of Microscopic Objectives."

"On Phenomena of Interference in the Microscope."

"On Diffraction Spectra in the Microscope."

"Is there a Science of Microscopy?"

"Account of some Experiments on Insect Hearing."

Universally loved and esteemed, not less for his unwearied labours in the interest of the Society than for his uniform genial kindliness, Dr. Fripp was, not without much hesitation on his part, elected a Member of the Council at the annual meeting in May, 1868, and one of the Vice-Presidents in 1871. On the death of Mr. Wm. Sanders he was elected to the Presidential chair, which he most honourably occupied till he was suddenly taken from among us on March 23rd, 1880.

Phenological Records for 1891.

PLANTS.

Recorders: Miss Annie Baker, Bridgwater (A.B.); Mr. H. S. B. Goldsmith, Bridgwater (H.S.B.G.); Mr. David Fry, Corston (D.F.); Mr. R. M. Prideaux, Clifton (R.M.P.).

Abbreviations.—App., first appearance above ground; Bud. b., first buds bursting; Fol., almost in full foliage; Fl., first flower; R. fr., first ripe fruit.

1. *Anemone nemorosa* (*Wood Anemone*). — Fl. March 27th, Durleigh, near Bridgwater, H.S.B.G.; April 11th, Leigh Woods, R.M.P.

2. *Ranunculus ficaria* (*Lesser Celandine*).—Fl. by April 6th, Hamp, A.B.; March 21st, Long Ashton, R.M.P.

3. *Ranunculus acris* (*Upright Crowfoot*).—App. by Feb. 15th, Hamp, A.B.; Fl. May 16th, Clifton, R.M.P.

4. *Caltha palustris* (*Marsh Marigold*).—Fl. by April 20th, Durleigh, A.B.; 19th April, Petherton Marshes, Bridgwater, H.S.B.G.

7. *Cardamine pratensis* (*Cuckoo Flower*).—Fl. April 27th, Bridgwater, A.B.; April 26th, Durleigh, H.S.B.G.; April 11th, Failand, R.M.P.

8. *Alliaria officinalis* (*Jack-by-the-Hedge*).—Fl. April 17th, Hamp, A.B.; May 6th, Corston, D.F.

9. *Draba verna* (*Whitlow Grass*).—Fl. Feb. 17th, Corston (accelerated), D.F.

10. *Viola odorata* (*Sweet Violet*).—Fl. March 6th, Corston, D.F.; March 27th, Durleigh, H.S.B.G.; April 5th, Clifton Down, R.M.P.

11. *Polygala vulgaris* (*Milk-wort*).—Fl. June 17th, Clifton Down, R.M.P.

12. *Lychnis diurna* (*Red Campion*).—Fl. April 2nd, Hamp, A.B.; May 11th, Corston, D.F.

13. *Stellaria holostea* (*Stitchwort*).—Fl. April 15th, Hamp, A.B.; April 26th, Durleigh, H.S.B.G.; May 14th, Corston, D.F.; May 13th, Clifton Down, R.M.P.

14. *Cerastium pumilum* (*Mouse-ear*).—Fl. April 21st, Hamp, A.B.

15. *Malva sylvestris* (*Mallow*).—App. about Feb. 1st, Hamp, A.B.

16. *Tilia parvifolia* (*Small-leaved Lime*).—Bub. b. May 2nd; Fol. May 13th, Leigh Woods, R.M.P.

19. *Geranium Robertianum* (*Herb-Robert*).—App. by Feb. 25th, Hamp; Fl. May 13th, Corston, D.F.; May 23rd, Hamp, A.B.; May 23rd, Leigh Wood, R.M.P.

20. *Euonymus Europœus* (*Spindle-tree*).—Bud. b. April 8th, Corston, D.F.; by April 24th, Leigh, R.M.P.; Fl. June 17th; R. fr. 16th November, Leigh, R.M.P.

21. *Acer pseudo-platanus* (*Sycamore*).—Bud. b. March 23rd, Bridgwater, H.S.B.G.; March 29th, Clifton, R.M.P.; by April 5th, Bridgwater, A.B.; Fol. April 22nd, Bridgwater, H.S.B.G.; May 3rd, Clifton, R.M.P.

22. *Æsculus hippocastanum* (*Horse Chestnut*).—Bub. b. March 26th, Hamp, A.B.; March 25th, Bridgwater, H.S.B.G.; April 20th, Clifton, R.M.P.; Fol. April 30th, Hamp, A.B.; May 2nd, Bridgwater, H.S.B.G.; May 4th, Clifton, R.M.P.; Fl. May 14th, Clifton, R.M.P.

23. *Cytisus laburnum* (*Laburnum*).—Bub. b. March 28th, Bridgwater, H.S.B.G.; by April 21st, Bridgwater, A.B.; April 22nd, Clifton, R.M.P.; Fol. May 14th, Bridgwater, A.B.; April 25th, Bridgwater, H.S.B.G.; May 10th, Clifton, R.M.P.; Fl. May 27th, Clifton, R.M.P.

24. *Trifolium repens* (*Dutch Clover*).—Fl. by June 4th, Hamp, A.B.; June 17th, Clifton, R.M.P.

25. *Lotus corniculatus* (*Bird's-foot Trefoil*).—Fl. by May 23rd, Hamp, A.B.

27. *Vicia sepium* (*Bush Vetch*).—Fl. April 19th, Rhode Lane, A.B.; May 12th, Marksbury, D.F.; May 19th, Leigh Wood, R.M.P.

29. *Prunus spinosa* (*Sloe*).—Bud. b. March 27th, Bridgwater, H.S.B.G.; May 5th, Clifton, R.M.P.; Fol. May 17th, Clifton, R.M.P.; Fl. by April 15th, Huntstile, A.B.; April 20th, Bridgwater, H.S.B.G.; May 5th, Clifton, R.M.P.; May 6th, Corston, D.F.

31. *Potentilla anserina* (*Silver-weed*).—App. by April 12th; Fl. by June 14th, Hamp, A.B.

32. *Rosa canina* (*Dog Rose*).—Bud. b. March 27th, Durleigh, H.S.B.G.; by March 30th, Rhode, A.B.; April 16th, Clifton, R.M.P.; Fol. April 21st, Rhode, A.B.; May 2nd, Clifton, R.M.P.; Fl. May 14th, Rhode, A.B.

33. *Pyrus aucuparia* (*Rowan*).—Bud. b. April 17th, Clifton, R.M.P.; by April 27th, Bridgwater, A.B.; Fol. May 5th, Clifton, R.M.P.; May 9th, Bridgwater, A.B.; Fl. by May 27th, Bridgwater, A.B.

34. *Pyrus aria* (*White-beam*).—Bud. b. May 4th, Leigh Wood; Fol. May 15th, R.M.P.

35. *Cratægus oxyacantha* (*Hawthorn*).—Bud. b. March 27th, Durleigh, H.S.B.G.; April 20th, Clifton, R.M.P.; Fol. April 21st, Hamp, A.B.; May 3rd, Clifton, R.M.P.; Fl. May 26th, Clifton, R.M.P.

36. *Epilobium hirsutum* (*Great Hairy Willow-herb*).—App. by April 6th, Hamp, A.B.

41. *Cornus sanguinea* (*Dog-wood*).—Bub. b. April 28th, A.B.; May 3rd, Leigh, R.M.P.; Fol. May 23rd; R. fr. about October 21st, Leigh, R.M.P.

42. *Adoxa Moschatellina* (*Moschatel*).—Fl. by April 17th, Durleigh, A.B.

43. *Syringa vulgaris* (*Lilac*).—Bud. b. Feb. 2nd, Bridgwater, H.S.B.G.; Feb. 19th, Bridgwater, A.B.; Feb. 22nd, Corston, D.F.; March 31st, Clifton, R.M.P.; Fol. April 30th, Bridgwater, A.B.; April 26th, Bridgwater, H.S.B.G.; May 2nd, Clifton, R.M.P.; Fl. by May 12th, Bridgwater, A.B.; May 12th, Corston, D.F.; May 14th, Clifton, R.M.P.

44. *Galium aparine* (*Cleavers*).—App. by Feb. 16th, Rownham Hill, R.M.P.; Fl. by May 20th, Hamp, A.B.

45. *Galium verum* (*Yellow Bedstraw*).—App. May 8th; Fl. June 29th, Clifton, R.M.P.

48. *Petasites vulgaris* (*Butterbur*).—App. by January 26th, Hamp, A.B.; by April 5th, L. bank of Avon, R.M.P.; Fl. January 31st, Hamp, A.B.; March 26th, Goathurst, H.S.B.G.

50. *Tussilago farfara* (*Coltsfoot*).—Fl. Feb. 17th, Corston, D.F.; by March 4th, L. bank of Avon, R.M.P.; April 5th, Bridgwater, H.S.B.G.

51. *Achillea millefolium* (*Yarrow*).—App. Feb. 15th, Hamp, A.B.

52. *Chrysanthemum leucanthemum* (*Ox-eye*).—Fl. June 2nd, L. bank of Avon, R.M.P.

54. *Senecio Jacobea* (*Ragwort*).—App. by April 16th; Fl. July 19th, Clifton, R.M.P.

55. *Centaurea nigra* (*Knapweed*).—Fl. July 19th, Leigh, R.M.P.

60. *Campanula rotundifolia* (*Hairbell*).—Fl. June 29th, St. Vincent Rocks, R.M.P.

61. *Ligustrum vulgare* (*Privet*).—Fl. May 30th, Hamp, A.B.; July 1st, Clifton, R.M.P.

62. *Convolvulus sepium* (*Great Bindweed*).—Fl. August 9th, Clifton, R.M.P.

63. *Symphytum officinale* (*Comfrey*).—Fl. by May 30th, Hamp, A.B.

64. *Pedicularis sylvatica* (*Red Rattle*).—Fl. May 23rd, Leigh, R.M.P.

65. *Veronica Chamædrys* (*Germander Speedwell*).—Fl. April 11th, Hamp, A.B.; May 23rd, Leigh, R.M.P.

69. *Nepeta Glechoma* (*Ground Ivy*).—Fl. March 29th, Hamp, A.B.; April 5th, L. bank of Avon, R.M.P.; April 6th, Corston, D.F.

70.—*Lamium galeobdolon* (*Archangel*).—Fl. May 19th, Leigh Wood, R.M.P.

72. *Ajuga reptans* (*Bugle*).—Fl. May 15th, Leigh, R.M.P.

73. *Primula veris* (*Cowslip*).—Fl. April 17th, Bridgwater, H.S.B.G.; April 19th, Hamp, A.B.; May 8th, Corston, D.F.; May 8th, Leigh Wood, R.M.P.

74. *Plantago lanceolata* (*Ribwort*).—Fl. April 29th, Hamp, A.B.; May 4th, Clifton, R.M.P.

75. *Mercurialis perennis* (*Dog's Mercury*).—App. by Feb. 26th; Fl. (male specimen selected) by March 21st, Leigh, R.M.P.

76. *Ulmus montana* (*Wych-elm*).—Bud. b. May 3rd; Fol. May 12th; Fl. by March 7th, Clifton, R.M.P.

77. *Salix caprea* (*Great Sallow*).—Bud. b. April 24th; Fol. May 6th; Fl. (male specimen selected) March 7th, Leigh, R.M.P.

78. *Fagus sylvatica* (*Beech*).—Bud. b. April 30th, Taunton Road, A.B.; May 5th, Clifton, R.M.P.; Fol. May 15th, Clifton, R.M.P.

79. *Corylus avellana* (*Hazel*).—Bud. b. March 27th, Bridgwater, H.S.B.G.; Fl. by Feb. 1st, Leigh, R.M.P.; Feb. 18th, Corston, D.F.; April 5th, Durleigh, H.S.B.G.

82. *Narcissus pseudo-narcissus* (*Daffodil*).—Fl. March 27th, Durleigh, H.S.B.G.; by April 10th, Failand, R.M.P.

83. *Galanthus invalis* (*Snowdrop*).—Fl. by March 21st, Dundry, R.M.P.

84. *Scilla nutans* (*Blue-bell*).—Fl. April 20th, Durleigh, A.B.; May 6th, Leigh Wood, R.M.P.; May 11th, Corston, D.F.

A Few Additional Species Observed.

Carpinus betulus (*Hornbeam*).—Bud. b. May 3rd; Fol. May 19th, Leigh, R.M.P.

Rhamnus catharticus (*Buckthorn*).—Bud. b. May 4th; Fl. (stamens selected) May 15th, Leigh, R.M.P.

Fraxinus excelsior (*Ash*).—Bud. b. May 14th; Fol. May 28th; Fl. May 9th, Clifton, R.M.P.

Atropa belladonna (*Deadly Nightshade*).—R. fr. Sept. 30th, Leigh Woods (previously unrecorded from this locality), R.M.P.

LATE FLOWERING OF CERTAIN SPECIES DURING THE AUTUMN, 1891.

October 16th.—One spike of *Ajuga reptans*, Leigh Wood.

October 28th.—Hypericum perforatum, Solidago virgaurea, and Lysimachia nemorum.

November 1st.—Helianthemum vulgare, Scabioso succisa, S. columbaria, Erodium circutarium.

November 3rd.—Cornus sanguinea.

November 7th.—Campanula rotundifolia, Viburnum lantana.

November 17th.—Lychnis diurna.

November 19th.—Erythrea centaurea.

December 15th.—Geranium dissectum and G. rotundifolium.

R. M. PRIDEAUX.

BIRDS.

Observer : H. S. B. GOLDSMITH, Esq., Bridgwater.

ABBREVIATIONS.—*Seen*, first seen ; *song*, note or song first heard ; *nest*, building of nest commenced ; *eggs*, eggs first noticed; *hatch*, young hatched ; *y. fly*, young flying ; *leav.*, bird leaving locality.

1. *Strix aluco* (Brown Owl).—*Song*, Feb. 1st, Holford, near Bridgwater, late in the evening. *Eggs*, 20th April, Puriton, two eggs, hard set.

2. *Muscicapa grisola* (Flycatcher).—*Seen* 21st May, in the Square, Bridgwater, 24th May, looking out for a nesting site.

3. *Turdus musicus* (Song Thrush).—*Song*, 31st January, Holford ; *Nest*, 5th April, nest finished, Enmore.

4. *Turdus pilaris* (Fieldfare).—*Seen* 19th April, Bridgwater, two flocks.

6. *Daulias luscinia* (Nightingale).—*Song*, 3rd May, Bridgwater.

7. *Saxicola œnanthe* (Wheatear).—11th April, Carrodon Moor, Cornwall ; and 13th April, a large number at Porlock.

9. *Phylloscopus trochillus* (Willow-wren).—*Seen* 5th April, Enmore, near Bridgwater (only one). *Nest* and *Eggs*, 23rd May, Cossington, eight eggs fresh.

10. *Phylloscopus collybita* (Chiff-chaff).—*Seen* 11th April, Porlock. *Song*, 6th April, Dodrington. *Nest*, 23rd May, Bawdriss (not finished), on 2nd of June it contained five eggs. *Eggs*, May 31st, Goathurst, near Bridgwater; June 14th, Huntworth, six eggs highly incubated; Sept. 28th, Square in Bridgwater, a family of them in the garden, singing autumn note.

11. *Alauda arvensis* (Sky-lark).—*Song*, 31st Jan., Quantocks, above Holford.

12. *Emberiza schœniclus* (Reed Bunting).—*Seen* resident here throughout the year. *Eggs*, 5th June, three eggs, Petherton levels, near Bridgwater; June 7th, Wemborn, one egg (on June 12th, four eggs in the nest); 8th June, Petherton levels, five eggs, close to the one found on June 5th. *Hatch*, 21st June, three young birds.

14. *Emberiza cirlus* (Cirl Bunting).—*Seen* June 5th, Bawdrip, near Bridgwater, a pair.

15. *Fringilla cœlebs* (Chaffinch).—*Song*, 3rd May, the Square, its spring note. *Eggs*, 31st May, Goathurst, near Bridgwater, two nests, two eggs in each; June 7th, Wemborn, near Bridgwater, four eggs. *Hatch*, June 6th, Bawdrip, young just hatched, also one with young nearly fledged.

17. *Corvus frugilegus* (Rook).—*Hatch*, 19th March, Puriton, young birds in nests.

18. *Cuculus canorus* (Cuckoo).—*Seen* and *Song*, 24th April, at Kingston, near Taunton. *Eggs*, 30th May, Spaxton, near Bridgwater, in thrushes' nest, and 5th June, Bawdrip, near Bridgwater, in nest of yellowhammer.

19. *Hirundo rustica* (Chimney Swallow).—*Seen* 9th April, Dunball, near Bridgwater. *Y. fly*, 14th June, Pawlett, young on telegraph wire. *Leav.*, October 8th, Bridgwater, main body gone; Nov. 1st, fifteen to twenty swallows hawking round the trees in the Square —did not see them again.

20. *Hirundo urbica* (House Martin).—*Seen* by the 19th April, Bridgwater. *Hatch*, 7th October (saw martins feeding young in nest). *Y. fly.*, 14th July, Dunball, near Bridgwater. *Leav.*, 8th October (main body gone); 16th October, six birds flying S.E.; 26th October, two birds flying about town.

22. *Cypselus apus* (Swift).—28th April, Bridgwater. *Eggs*, 12th June, Wembdon, near Bridgwater; six nests, four with two eggs each. *Leav.*, 3rd September, Bridgwater (that night or early on morning of 4th).

24. *Columba turtur* (Turtle Dove).—*Eggs*, Huntworth, near Bridgwater, two eggs.

25. *Perdix cinerea* (Partridge).—*Seen* 31st January, at Holford, pairing. *Y. fly.*, 28th June, Huntworth, two old birds with young.

27. *Totanus hypoleucos* (Sandpiper).—*Seen* 13th April, Porlock.

28. *Crex pratensis* (Corncrake).—*Song*, 19th May, Dulverton.

INSECTS.

Recorders: Mr. G. C. Griffiths (G.C.G.), Clifton; Mr. C. Bartlett (C.B.), Redland; Mr. R. M. Prideaux (R.M.P.), Clifton.

Abbreviations.—*Ap.*, first appearance; *G.c.*, getting common.

1. *Cicindela campestris* (Tiger-beetle).—*Ap.* April 11th, Leigh, C.B.; April 17th, Leigh, R.M.P. *G.c.* April 26th, Gully, C.B.

2. *Melolontha vulgaris* (Cockchafer).—*Ap.* June 2nd, Leigh, G.C.G.; May 31st, Redland Green, C.B.; May 29th, Clifton. Abundant at gas-lamps after the 8th of June, R.M.P.

6. *Lampyris noctiluca* (Glow-worm).—*Ap.* June 18th, Leigh Down, C.B.; July 1st, the Gully, R.M.P.; common on July 4th, Leigh Down, and two females under stones in same locality, December 28th, C.B.

10. *Timarcha lævigata* (Blood-spitter).—*Ap.* June 14th, Redland Green, C.B.

12. *Cassida viridis* (Helmet-beetle).—On August 22nd, Slapton Lea, eight specimens on Artemesia absynthium, C.B.

13. *Coccinella bipunctata* (Lady-bird).—May 11th, G.C.G.; June 4th, C.B.; March 29th, R.M.P.

14. *Apis mellifica* (Hive Bee).—*Ap.* April 5th, Sea Mills, R.M.P.

15. *Vespa vulgaris* (Wasp).—*Ap.* a female Vespa (? sp.), April 6th, Clifton, R.M.P.

16. *Bibio Marci* (St. Mark's Fly).—*Ap.* May 19th. *G.c.* May 23rd, Leigh Wood; abundant for a few days, R.M.P.

17. *Pieris rapæ* (Small Cabbage Butterfly).—*Ap.* May 4th, G.C.G.; April 11th, Hallen, C.B.; May 6th, Leigh, R.M.P. *G.c.* from May 11th, second brood abundant, G.C.G. and R.M.P.

18. *Pieris napi* (Green-veined White Butterfly).—*Ap.* May 7th, R.M.P. Common, G.C.G.

19. *Pieris brassicæ* (Large White Butterfly).—*Ap.* May 14th, Clifton, R.M.P. *G.c.* May 31st, Leigh Wood, G.C.G., abundant.

20. *Anthocharis cardamines* (Orange Tip).—*Ap.* May 6th, Coombe Dingle, fem., C.B. *G.c.* June 9th, Dursley; rare at Leigh, and in the immediate neighbourhood of Clifton, R.M.P.

21. *Epinephile janira* (Meadow-brown).—*Ap.* June 20th, Portishead, R.M.P. *G.c.* July 1st, R.M.P.

23. *Amphidasys prodromaria* (Oak-beauty Moth).—*Ap.* April 6th, Leigh Wood, G.C.G. and R.M.P. Occasionally seen till May 5th, but never abundant here.

24. *Tephrosia crepuscularia* (Small Engrailed Moth).—*Ap.* April 25th, Leigh Wood. *G.c.* May 5th till May 19th, several specimens

unusually dark, G.C.G. *Ap.* May 5th, C.B.; April 11th, an unusually early date, R.M.P.

25, 26, 27, 28, and 29. Genus *Tæniocampa.*—Abundant from 6th April till 20th, G.C.G. Seen on April 1st, R.M.P., C.B.

30. *Brephos parthenias* (Orange Underwing Moth).—*Ap.* March 30th, Leigh Woods, rather abundant, G.C.G.; March 31st, Leigh, C.B.; March 25th, R.M.P.; abundant from 31st March, R.M.P.

31. *Diurnea fagella.*—*Ap.* April 4th, R.M.P.; April 10th, G.C.G.; abundant and variable until April 30th, G.C.G. and R.M.P.

The season of 1891, from a Lepidopterist's point of view, was, though in some respects disappointing, a busy one, on the whole, in this neighbourhood. An excursion of the Entomological section of the Bristol Naturalists' Society to Dursley on the 9th of June was quite a success; over forty species of Macro-lepidoptera being recorded, several of which are not met with in the immediate neighbourhood of Bristol.

My own most interesting capture was a specimen of *Lithosia quadra*, at a gas-lamp, on the 9th August, a species of which only one specimen has been previously recorded from this locality.

R. M. Prideaux.

The spring of 1891, regarded from an Entomological point of view, was decidedly a late one, many species being quite a fortnight or three weeks after the dates recorded in 1890. The season began well in spite of this, as insects were in far greater abundance than in the previous year, and sugaring in many places was successful, though of this I had but little personal experience. As the summer progressed, however, the almost continuous wet weather had its effect: sugar became an utter failure, except on very rare occasions, and larva-beating was very unproductive. In this last respect the month of September showed an improvement, the larvæ of several species being in almost

greater abundance than usual; and it may not be out of place to record here the capture of four larvæ of our local Hook-tip (*Platypteryx Sicula*) in Leigh Woods by Mr. Grigg and myself, and one by Mr. W. K. Mann, the species not having been taken for several years previously. As regards the later autumn months, it appears to be agreed by Entomologists generally throughout the country that they were most disappointing, wind and rain combining to make the lure of ivy-bloom almost useless.

Geo. C. Griffiths.

Rainfall at Clifton in 1891.

By GEORGE F. BURDER, M.D., F.R.Met.Soc.

TABLE OF RAINFALL.

	1891.	Average of 38 years ending 1890.	Departure from average	Greatest Fall in 24 Hours.		Number of Days on which ·01 in. or more fell.
				Depth.	Date.	
	Inches.	Inches.	Inches.	Inches.		
January . .	3·830	3·212	+0·618	1·903	23rd	15
February .	0·003	2·213	−2·210	0·002	2nd	0
March . .	2·797	2·252	+0·545	0·702	9th	15
April . . .	1·228	2·117	−0·889	0·344	2nd	9
May . . .	3·776	2·399	+1·377	0·594	24th	19
June . . .	2·319	2·551	−0·232	0·782	25th	13
July . . .	3·186	3·051	+0·135	0·820	2nd	15
August . .	7·439	3·410	+4·029	1·477	20th	22
September .	2·328	3·238	−0·910	0·298	6th	18
October . .	8·494	3·561	+4·933	1·225	17th	22
November .	2·494	3·050	−0·556	0·620	10th	14
December .	4·627	2·834	+1·793	0·721	13th	20
Year . . .	42·521	33·888	+8·633	1·903	Jan. 23rd	182

Remarks: August, 1891, was the wettest August since 1865.
October, 1891, was the wettest month since August, 1865.

Observations of Temperature at Clifton College in 1891.

By D. RINTOUL, M.A.

THE results of the daily observations of temperature taken at Clifton College in the year 1891 are summarized in the following tables. It is regretted that the temperature curves which were printed in the Proceedings of last year cannot be given this year on account of the expense, but the outstanding features of the year's weather can be gleaned from the tables. It will be noticed that the mean temperature of 1891 is about half a degree lower than the average of the last ten years. The months which were colder than usual were January, March, April, May, July, August, and November. Of these, January was by far the coldest, its mean temperature being nearly four degrees below the average for the month, and with the exception of January, 1886, the coldest January in the last ten years. Another remarkable fact is that there was frost on the ground every day from the beginning of the month till the 23rd. In February there was not much deviation from the normal, the most striking meteorological feature of the month being the almost complete absence of rain. In March there was a period of extremely cold weather, extending from the 8th till the 24th. There was nothing specially worthy of notice in the temperature of April. In May there

were three very hot days—the 11th, 12th, and 13th—followed by a period of cold weather. June was warmer than usual by more than a degree; the highest temperature reached was 77° on the 19th. Both in July and August the temperature was fairly uniform, there being no exceptionally hot or cold days; but both months were colder than usual. In September, however, there was a period of very hot weather, the temperature being above the average from the 8th till the 21st. There were only five days on which the temperature was below the average. The highest temperature recorded during the whole year was 79·1° on the 12th of this month. The temperature of October presented no special features. In the end of November there was a period of very cold weather, from the 23rd till the end of the month. In December the temperature was considerably above the average till the 18th, when a period of exceptionally cold weather set in, with frost on the ground till the 28th. The mean temperature was below freezing point from the 20th till the 25th.

It is to be noted that the situation of the thermometers was changed in April. There was also an interruption in the observations of ground temperature from the 28th of October till the 1st of November on account of the breakage of the thermometer. The lowest ground temperature for December is also uncertain on account of the falls of snow.

In conclusion I would draw attention to an error in the table of Mean Temperatures for 1890, on page 293 of the last volume of the Proceedings of the Society. The mean temperature of the last ten Aprils ought to be 46·15°, instead of 44·14° as then stated. My attention was drawn to this error by the late Dr. Burder, and I cannot but seize this opportunity of expressing my sense of the loss which students of meteorology have sustained in his lamented death.

1891 TEMPERATURES.

MONTH.	Maximum in Shade.		Minimum in Shade.		Mean in Shade.	Minimum on Ground.
	Highest recorded.	Mean.	Lowest recorded.	Mean.		
January .	54·7	41·49	15·2	30·18	35·84	15·2
February .	63·1	49·52	29·6	34·53	42·03	25·3
March . .	53·0	44·66	21·6	34·45	39·56	18·3
April . .	59·9	51·83	31·0	37·89	44·86	25·7
May. . .	76·5	57·14	34·2	42·92	50·03	32·2
June . .	77·1	67·56	44·5	52·68	60·12	42·7
July. . .	74·3	65·78	49·4	54·00	59·89	47·3
August .	68·6	63·45	44·0	53·10	58·27	44·0
September	79·1	64·42	46·1	52·94	58·68	42·4
October .	61·5	55·29	31·7	45·40	50·34	?
November	56·5	47·70	28·2	37·97	42·83	26·0
December.	57·3	46·19	21·0	36·34	41·26	24·9(?)
Year 1891	79·1	54·59	15·2	42·70	48·64	15·2

Year 1890.	76·0	55·16	19·1	43·40	49·28	17·2
Year 1889.	80·5	55·22	22·2	43·60	49·41	18·2
Year 1888.	79·1	54·19	22·3	42·74	48·45	18·0
Year 1887.	82·8	56·0	20·4	40·9	48·4	11·7
Year 1886.	83·5	54·90	21·7	43·17	49·03	15·3
Year 1885.	87·8	53·98	22·1	42·53	48·09	20·1
Year 1884.	87·5	57·44	22·6	44·07	50·66	23·7
Year 1883.	82·5	54·54	20·9	42·88	48·71	19·3
Year 1882.	78·5	55·46	21·9	43·62	49·54	20·6
Year 1881.	86·9	55·44	12·3	42·92	49·18	5·8

MONTH.	Number of Days on which the Minimum Ground Temperature was below 32°F.	Number of Days on which the Minimum Air Temperature was below 32°F.	Number of Days on which the Maximum Air Temperature was below 32°F.	Number of Days on which the Mean Air Temperature was below 32°F.
January . .	23	18	3	13
February. .	19	9	0	0
March. . .	17	11	1	2
April . . .	3	1	0	0
May . . .	0	0	0	0
June . . .	0	0	0	0
July . . .	0	0	0	0
August . .	0	0	0	0
September .	0	0	0	0
October . .	?	1	0	0
November .	8	8	0	0
December .	13	9	4	5
Year 1891 .	83	57	8	20
Year 1890 .	79	57	16	31
Year 1889 .	88	45	5	12
Year 1888 .	93	60	2	16
Year 1887 .	148	63	2	11
Year 1886 .	102	64	1	22
Year 1885 .	68	40	1	6
Year 1884 .	51	19	0	1
Year 1883 .	79	40	0	6
Year 1882 .	63	26	2	7
Year 1881 .	94	60	11	24

MEAN SHADE TEMPERATURES OF THE MONTHS.

MONTH.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	Mean of last Ten Years.
January . .	40·7	42·3	44·2	38·7	35·5	41·5	38·5	37·16	43·76	35·84	39·82
February .	42·6	43·3	42·3	44·0	35·8	41·0	36·1	38·96	38·71	42·03	40·48
March . .	45·7	37·0	44·9	41·7	40·1	39·9	38·6	41·50	44·68	39·56	41·36
April . . .	48·8	47·5	45·1	46·7	46·4	42·2	44·1	46·07	47·33	44·86	45·91
May . . .	53·7	49·9	53·3	47·0	52·2	45·5	52·5	55·79	54·92	50·03	51·48
June . . .	56·0	57·2	59·8	58·4	58·8	62·4	57·9	61·29	57·54	60·12	58·95
July . . .	59·6	57·2	60·7	62·6	62·7	63·9	58·4	61·08	59·14	59·89	60·52
August . .	60·2	60·6	64·5	57·5	59·1	60·4	59·3	59·18	59·38	58·27	59·34
September .	53·9	55·3	59·4	54·5	58·2	53·7	57·3	56·93	59·67	58·68	56·76
October . .	50·2	49·6	48·9	45·6	52·9	46·1	48·8	48·79	51·25	50·34	49·25
November .	43·7	42·8	41·6	43·3	47·1	41·2	47·2	46·72	44·88	42·83	44·13
December .	39·8	41·4	43·1	38·8	38·6	39·9	42·7	39·44	30·12	41·26	39·51
The Year .	49·5	48·7	50·7	48·1	49·0	48·4	48·45	49·41	49·28	48·64	49·02

Rainfall and Floods.

By GEORGE F. BURDER, M.D., F.R.Met.Soc.

Read at the General Meeting, Feb. 6th, 1892.

THE practical interest attaching at the present time to the question of floods in Bristol must be my excuse for bringing this subject before the members of the Bristol Naturalists' Society. This practical interest is of course centred in the methods by which floods may be prevented; and as a consideration of these methods involves questions of engineering, it may be thought presumptuous on my part to undertake a discussion of the subject. The subject, however, is so far meteorological that nothing quite satisfactory can be done in it without accurate observation and record of local rainfall continued for a long series of years, and in that respect I may perhaps claim to have some special advantages, my record being now in its fortieth year without a break. And as regards the engineering aspect of the subject, if my remarks should succeed in eliciting the views of some of our engineering members, the evening will not have been lost.

The method of measuring rain is known, I suppose, in its general features to most persons. I need not describe it in detail. I will only say that the object in view is to ascertain the depth to which the rain would lie on a level surface if none of it either ran off or soaked in or evapo-

rated. This object might be gained very roughly by exposing any flat-bottomed vessel with vertical sides and simply measuring the depth of water that had collected within it. But much more accurate results may be obtained by collecting the rain which falls over an area of known dimensions (for example, a circle of eight inches diameter), and measuring it in a vessel of much smaller diameter, graduated in accordance with its relation to the area of the receiving surface. In this way we may easily measure the depth to the thousandth of an inch.

The principal floods which are liable to occur in Bristol are those which are due to an overflow of the river Frome; and before an engineer can have the necessary data for determining the provision that should be made for preventing such overflow, he must ascertain the maximum quantity of water which the channel of the Frome may under any circumstances be called upon to carry and discharge.

This, then, is the problem to be solved. Put in a precise form, what we want to know is the maximum number of cubic feet of water per hour that the Frome may be required to discharge after the heaviest rains, if the city is to be saved from flood. The first step in this inquiry is to find the extent of country which the river Frome drains, or, in technical language, the area of the Frome basin.

The area of the Frome basin is considered to be 68 square miles. This being known, it is easy to calculate the number of cubic feet of water which will fall over the Frome basin for every inch depth of rain. In a square mile there are (roughly) 28 million square feet. Twelve inches of rain over a square mile would therefore mean 28 million cubic feet of water, and one inch of rain would be a twelfth part of that,—namely, about 2,300,000,—or (to put it shortly) 2·3 million cubic feet of water. Multi-

plying this by the number of square miles (68) we get 156, or, more accurately, 158 million cubic feet as the quantity of water which will fall over the Frome basin for every inch of rain.

This is all simple enough, but we are only at present on the threshold of the inquiry. The later stages of it bristle with difficulties—difficulties which I venture to think have hardly been sufficiently considered by some of the eminent engineers whose opinions have been sought. I am emboldened to say so much as this by observing the very wide divergences of opinion expressed by engineers with regard to the provision which should be made for carrying off the flood-water of the Frome after heavy rains.

A former engineer of the Bristol Docks, Mr. Howard, held that 8 million cubic feet per hour might be taken as the maximum discharge for which provision should be made. A more recent opinion has been given, I am told, that safety will not be secured until provision is made for the discharge of from 18 to 21 million cubic feet per hour—an estimate which appears the more remarkable when contrasted with an important observation of Mr. McCurrick, the present engineer of the Docks, on the 19th of October last, showing that a discharge of less than $4\frac{1}{2}$ million cubic feet per hour sufficed on that occasion to prevent flood,—the occasion being one which, if not strictly crucial as an experiment, was at least very exceptional in character.

It is well known that the volume of water discharged by a river in a given interval of time—say a year—is very much less than the volume of rain which falls in the same interval over the basin of that river. A similar result is found in what are known as percolation experiments. A cylinder or a tank from 2 to 5 feet in depth is filled with

earth and exposed to the rain, provision being made at the bottom of the cylinder or tank for letting off and collecting in a separate vessel the water which runs through. The quantity of water which under such an arrangement percolates through the soil is found to be very much less than the quantity that falls. In some experiments the proportion has been no more than 20 or 25 per cent. in the whole year. In other experiments it has been about 50 per cent. In the summer months it may be only 10 per cent., or even less than that. These facts, which have been known from the time of Dalton, are justly considered of great importance in their bearing upon questions of water supply.

What becomes of the rain that does not percolate? There can, I think, be but one answer. It is lost by evaporation. One sometimes reads in this connection of "absorption and evaporation," as if these two processes were two distinct causes of loss. This, I think, is not an accurate mode of expression as applied to average results or results of long period. Much—probably most—of that which is lost by evaporation is first absorbed, the water subsequently rising by capillary action, in every dry interval of weather, from the deeper and moister soil, and evaporating from the surface, while (in nature's experiments) a still larger portion, perhaps, is taken up by the roots of plants and evaporated from their leaves. But absorption itself cannot be the cause of any permanent loss for the simple reason that it is not a cumulative process. The amount of water held in the surface soil and the subjacent strata will be the same at the end of a period as it was at the beginning, or if there should in any case be such a difference as materially to affect the result, it will only show that the period taken for observation has not been long enough to eliminate accidental error arising from variation of seasons.

These considerations obviously bear chiefly upon questions of water supply, but it is necessary to introduce them here in order to point out the differences to be observed in the discussion of questions of water supply on the one hand and questions of flood on the other.

In discussing a question of flood, evaporation may be left out of account altogether, for the amount of evaporation during rain is practically nil. Absorption demands consideration, no doubt, but in quite a different sense from that in which evaporation has to be considered in a question of water supply. The loss of water by evaporation in a question of water supply may be expressed with approximate accuracy in figures, and, if necessary, may be reduced to a percentage. The effect of absorption on a particular rainfall in a question of flood admits of no such treatment. The proportion of rain which is held back by the soil and strata will depend entirely upon the previous condition of these in regard of moisture; it will therefore differ greatly in different cases, and can only be roughly estimated by a reference to the weather which has prevailed during preceding days or weeks or months, or, with less trouble, by a reference to the state of the river before the rainfall, which state will faithfully tell the tale of the previous weather.

It may be said that, to ensure safety from flood, we should assume the extreme case of complete saturation of the soil and strata at the commencement of the rainfall. But complete saturation cannot be except after long-continued and heavy rain, and therefore cannot exist at the *commencement* of a rainfall, unless by an arbitrary arrangement we exclude from the rainfall which we take as the basis of our calculation such portion of it as we may consider sufficient to saturate the ground. But any such proceeding would (as

it seems to me) be without practical advantage. And when the question is asked (as it sometimes is asked), what proportionate deduction for absorption should be made from the total rainfall as the first step in calculating its effect upon the river? I am disposed to reply, that if at the commencement of the rainfall the soil and strata were in an average state of moisture, then the whole of the rainfall (or an equivalent quantity of water) would be sooner or later discharged by the river; if the soil and strata were below their average state of moisture, the discharge would be less than the total rainfall by the proportion which would suffice to supply what was wanting in the soil and strata; if, on the other hand, the soil and strata held at the commencement of the rainfall more than their average amount of water, then the total extra discharge by the river which would follow the rainfall would be equal to the total amount of the rainfall plus the superabundant moisture of the soil and strata. In other words, the extra discharge following a particular rainfall will be equal to the rainfall, less than the rainfall, or more than the rainfall, according to the previous condition of the soil and subjacent strata in regard of moisture.

I very much doubt whether the question admits of a more precise *general* answer than this, nor do I believe that in any *particular* case the attempt to express numerically the addition or the deduction that should be applied to the total rainfall in consideration of the previous state of the soil and strata would be otherwise than vain. Further, I am disposed to maintain that if in any particular case the question I have asked could be answered precisely, nothing would be gained. The question of the occurrence of a flood will have been determined one way or the other long before the whole effect of the rainfall upon the river has passed

away. It matters not to our purpose what will be the total extra discharge of water by the river which will follow the downfall of rain. What we want to know is simply the maximum rate at which that discharge will take place. To assume (as some engineers appear to have done) that in order to obtain the rate of discharge it is only necessary to ascertain the number of cubic feet of water that have fallen over the area, to apply to that number a certain deduction for absorption, and to divide the number so reduced by the number of hours during which the rain fell, involves to my mind a double error. It assumes that the rate of discharge will be uniform, and it assumes that the discharge will occupy the same interval of time that the rain occupied in falling—assumptions both at variance with observed facts.

I have not at my command such a series of measurements of the height of water in the Frome after heavy rain as would prove this point, and I am aware that the phenomena of one river may differ very much from those of another river. But I have been favoured by a correspondent with some observations made on the height of the flood-water in the Avon above the Frome, which are interesting in themselves, and are sufficiently germane to the matter in hand to warrant their introduction here. They refer to the heavy rains of October last, and the observer is Mr. H. C. Martin.

From October 5th to October 22nd the fall of rain was almost exactly 8 inches. Between October 23rd and November 7th the entire fall was only a quarter of an inch. The rain may therefore be said to have ceased on October 22nd. Yet the fresh in the river Avon, which reached its highest level on October 23rd, had not entirely subsided on November 7th, sixteen days from the cessation of the rain. It may be that in the Frome the period of subsidence of the

fresh after heavy rains is much shorter than in the Avon. Still, I think it will be admitted that these observations show that the question of what proportion of a particular rainfall will find its way to the mouth of the river over the basin of which it falls is one which, if it could be answered (which I believe it cannot), has little or no bearing upon the question of flood.

I repeat that what we want to know is one thing only—it is the maximum rate at which the flood-water will require to be discharged. At the time when this maximum rate—this moment of danger—occurs, it is likely enough that not more than half of the entire rainfall will have been discharged.

So far, my remarks have been open to the charge of being little more than a kind of "destructive criticism." I have shown "how not to do it." I am not sanguine that I have much to offer in the way of positive help towards the solution of the problem which now presses for solution. But considering the extreme uncertainty of *à priori* conclusions—an uncertainty inherent, as I believe, in the nature of the case, and abundantly exemplified by the divergence of opinion amongst experts—I propose to consider whether some more definite clue may not be gathered from actual observations.

Obviously, in a case of flood, it is not possible to ascertain by actual observation what the maximum rate of discharge of water by the river would have been if the discharge had been sufficiently free to prevent flood. But there are cases in which, as the result of heavy rain, the river *almost* overflows, or, it may be, *just* overflows; and if we know what the maximum rate of discharge has been in such cases, and compared the conditions of the rainfall then with the conditions of the rainfall at times when

disastrous floods have been produced, I think we might possibly be in a position to check in a rough way the conclusions of the engineers.

It is in this sense that Mr. McCurrick's observation, already referred to, seems to me particularly valuable.

On the 19th of October last we were no doubt on the verge of a flood, and a flood we should have had but for the vigilance of the Docks engineer in lowering the level of the water in the Floating Harbour as the tide in the Avon permitted. Between 7 p.m. and 9.45 p.m. on that day—the interval during which the sluices of the Floating Harbour were closed on account of the tide in the Avon having risen above the level of the water in the Float—the level of the water in the Float was raised by the discharge from the Frome to the extent of 3 feet 6 inches. Mr. McCurrick, knowing the area of the Floating Harbour, was able to calculate that the entire quantity of water so discharged in $2\frac{3}{4}$ hours amounted to about $11\frac{3}{4}$ million cubic feet. The rate of discharge was uniform during that interval of time, and that rate was the maximum rate, because the river Frome was then at its maximum height. This maximum rate was 4·3 million cubic feet per hour.

Now what were the conditions of the rainfall which produced this maximum rate of 4·3 million cubic feet per hour? I have already said that they were not such as to furnish a crucial experiment, although they were in some respects very exceptional. They may be gathered from an inspection of the table on next page.

The rainfall specially concerned in producing a state of things so near to a flood was that which is set down to the four days from the 16th to the 19th of the month. The sum of the falls on these four days was 2·8 inches. But in considering rainfall with reference to flood it is necessary to

be precise as to the duration of the fall. In this case the rain which is set down in the table to four days fell within an interval of less than three days, namely, between 6 p.m. on the 16th and 11 a.m. on the 19th, actually 65 hours.

We have several times had heavier rains than this. I submit for comparison two examples, being those which occasioned the two greatest Bristol floods that have occurred in modern times.

Here is the rainfall for a portion of the month of March, 1889. On the 6th, 7th, and 8th of that month, 3·2 inches fell in 48 hours. In the table the fall is distributed over three days, but as it took place between the limits of midnight on the 6th and midnight on the 8th, the actual interval was only 48 hours.

Here again is shown the rainfall which produced the flood of October, 1882. On that occasion 3·7 inches fell in 60 hours, namely, from midnight of the 21st to noon of the 24th.

RAIN, OCTOBER, 1882.

	Inches.	
Oct. 11.	0·3	
,, 12.	0·0	
,, 13.	0·0	1·0.
,, 14.	0·0	
,, 15.	0·7	
,, 16.	0·3	
,, 17.	0·0	
,, 18.	0·2	0·7.
,, 19.	0·2	
,, 20.	0·0	
,, 21.	0·4	
,, 22.	1·2	3·7 in 60 hours.
,, 23.	1·8	
,, 24.	0·3	
,, 25.	0·0.	
,, 26.	0·1.	
,, 27.	0·2.	

RAIN, MARCH, 1889.

	Inches.	
Feb. 24.	0·0	
,, 25.	0·0	
,, 26.	0·0	0·1.
,, 27.	0·1	
,, 28.	0·0	
Mar. 1.	0·0	
,, 2.	0·0	
,, 3.	0·0	0·3.
,, 4.	0·3	
,, 5.	0·0	
,, 6.	0·5	
,, 7.	0·9	3·2 in 48 hours.
,, 8.	1·8	
,, 9.	0·0.	
,, 10.	0·0.	
,, 11.	0·0.	
,, 12.	0·0.	

RAIN, OCTOBER, 1891.

	Inches.	
Oct. 6.	1·1	
,, 7.	0·1	
,, 8.	0·1	2·0.
,, 9.	0·4	
,, 10.	0·3	
,, 11.	0·1	
,, 12.	0·1	
,, 13.	0·3	1·2.
,, 14.	0·4	
,, 15.	0·3	
,, 16.	0·5	
,, 17.	1·2	2·8 in 65 hours.
,, 18.	1·0	
,, 19.	0·1	
,, 20.	0·3.	
,, 21.	0·7.	
,, 22.	0·5.	

The total flood rainfall was heavier therefore, both in March, 1889, and in October, 1882, than it was in last

October, and it also fell in each case within a shorter interval of time. There was another circumstance attending the fall in March, 1889, which no doubt contributed materially to render the flood of that month the highest on record. Out of the total quantity of 3·2 inches falling in 48 hours, nearly an inch and a half fell within 8 hours, implying a rate of fall during that time nearly three times as great as the average rate of the entire fall. There was yet another feature about the rainfall of March, 1889, calculated to increase the danger. A fall of snow had occurred two days before the rain, and although this had so far melted that the quantity remaining on the ground when the rain commenced was too small to be in itself of much account, there can be little doubt that the ground was frozen underneath it, and therefore in an unfavourable condition for absorbing water.

On the other hand, in comparing the fall of last October with these two other falls, it should be noted that the first-named was the culmination of a long succession of rains to which we find no parallel in the other cases. The rainfall of March, 1889, was almost isolated. In October, 1882, although the principal rain was preceded by smaller falls, these were not nearly to the same amount as those which preceded the special rainfall of last October. To show this at a glance, the rains of the ten preceding days have in each case been grouped into two divisions.

Weighing these several considerations one against the other, we are, I think, in a position to form some sort of idea of what the maximum rate of discharge would have been in October, 1882, and in March, 1889, if the arrangements had then been such as to permit of the whole quantity of water being discharged without overflow of the river. In a matter of so much uncertainty one hesitates to name

a figure, but it can scarcely be rash to say that it is difficult to believe in the necessity, on those occasions, of a provision more than 50 per cent. beyond that which sufficed in October last. Provision for the discharge of 4·3 million cubic feet of water per hour sufficed in October last. Provision of $6\frac{1}{2}$ million cubic feet per hour would, I imagine, have sufficed to prevent the two greatest floods that have occurred in forty years, and, *à fortiori*, all the smaller floods.

The problem may be attacked in another way. A certain proportion exists in every case between the maximum rate of discharge and the average rate of fall. This proportion cannot be constant, but, with the exception of certain cases to be noticed immediately, I am disposed to think it makes a sufficient approach to constancy to serve as a rough guide. Let us see what the proportion was in October last.

The fall of rain in 65 hours on that occasion was 2·8 inches. The volume of water precipitated over the 68 square miles of the Frome basin was therefore about 442 million cubic feet. The average rate of the fall per hour was 6·8 million cubic feet. We have seen that the maximum rate of discharge was 4·3 million cubic feet per hour. The ratio of these two numbers is as 1·58 to 1.

Applying this ratio to the rainfall of March 6th to 8th, 1889, we get for the maximum rate of discharge 6·7 million cubic feet per hour.

Treating in the same manner the rainfall of October 22nd to 24th, 1882, we get for the maximum rate of discharge 6·2 million cubic feet per hour.

The calculation may be otherwise expressed in the forms following :—

OBSERVED.

Rainfall, October 16th to 19th, 1891 = 2·8 inches in 65 hours.

Volume over Frome basin = 442 million cubic feet.

Average rate of fall $= \frac{442}{65} = 6{\cdot}8$ million cubic feet per hour.

Maximum rate of discharge $= \frac{442}{65 \times 1{\cdot}58\,(=103)} = 4{\cdot}3$ million cubic feet per hour.

CALCULATED.

Rainfall, March 6th to 8th, 1889 = 3·2 inches in 48 hours.

Volume over Frome basin = 506 million cubic feet.

Average rate of fall $= \frac{506}{48} = 10{\cdot}54$ million cubic feet per hour.

Maximum rate of discharge $= \frac{506}{48 \times 1{\cdot}58\,(=76)} = 6{\cdot}7$ million cubic feet per hour.

Rainfall, October 22nd to 24th, 1882 = 3·7 inches in 60 hours.

Volume over Frome basin = 585 million cubic feet.

Average rate of fall $= \frac{585}{60} = 9{\cdot}75$ million cubic feet per hour.

Maximum rate of discharge $= \frac{585}{60 \times 1{\cdot}58\,(=95)} = 6{\cdot}2$ million cubic feet per hour.

These results, which profess to be nothing more than rough approximations to the truth, agree well enough with the impression already mentioned as derived from a more general view, and tend, I think, to throw considerable doubt on the estimates which some engineers have formed of the rate of discharge for which provision should be made.

In adopting the method I have suggested, it is necessary to use some discretion in selecting the period to be taken for the duration of the rainfall. In the case of an isolated rainfall, such as that of March, 1889, there is little room for discretion, but in a rainfall like that of last October the case is different. If in that instance we had included in the rainfall to be taken as the basis of calculation the rains of the 13th, 14th, and 15th days, or those of the 20th and 21st, we should have increased the duration in a much greater ratio than we should have increased the quantity, thus reducing the average intensity of the rain, or the average rate per hour, upon which the calculated rate of discharge depends.

The tables which I exhibit, apart from their primary object, may serve to show the kind of rain which in the past has occasioned floods in Bristol. Practically, any amount of rain might have fallen in the course of a month without flood if it had been pretty equally distributed. An inch of rain in a day would not, even under former conditions, have been a source of danger. Two inches in 24 hours, or three inches in 48 hours, would generally have caused a flood, and the flood would have been more serious in proportion to the irregular distribution of the rain within that interval of time.

A word must be added with regard to certain rainfalls which have considerably exceeded in intensity (not in quantity) those that I have selected for comparison. In July, 1875, 2·9 inches fell in 24 hours; and in August, 1865, a still more remarkable fall occurred of $2\frac{1}{4}$ inches in 4 hours. It must be admitted that my method of investigation, if applied to rainfalls such as these, especially to such as the last-named, would give results very different from those we have seen. But contemporary records furnish

no evidence that these rains were followed by more destructive floods than those which I have selected; while the general testimony of the time with reference to the floods of 1882 and 1889 is to the effect that each of these in its turn was the highest that had ever been known. This consideration alone would suffice to justify my selection, even if we were unable to see any reason why the exceptional rains I have referred to should be differently treated. But I think it is not difficult to discover several reasons why such rains do not produce effects in proportion to their violence. I will name a few which occur to me.

1. Such rains can scarcely occur but in connection with summer thunderstorms, when the soil and subjacent strata are likely to be in a specially receptive condition.

2. The time occupied in percolation will be equivalent to a material prolongation of the duration of the rain, the proportional prolongation being greater as the actual duration is less.

3. Such rains are always very local, and are not likely to be co-extensive with the area of even so small a river basin as that of the Frome.

4. The amount of flood in Bristol must be limited by the carrying capacity of the river Frome in its upper reaches, and the greater the overflow of these, the greater is the relief to Bristol.

To conclude, if I am not going beyond my province in pointing the moral of my story, I would say that to my mind it suggests the expediency of waiting until we see the full effect of the improvements which have been made, or are being made, in the channel of the Frome, before plunging into costly undertakings, the supposed necessity of which is based upon calculations that are at least open to question.

Note on the Fish Remains from the Old Red Sandstone of Portishead.

By E. J. L. GARDINER.

IN the "Proceedings of the Bristol Naturalists' Society" (Vol. II., No. 8, p. 79), some account is given of the occurrence of fish remains near the southern end of Woodhill Bay, near Portishead. The remains, which were very fragmentary, and were identified as scales of Holoptychius and Coccosteus, occurred in a bed three feet thick, coarsely conglomeritic at the top, but passing into fine sandstone lower down. This bed, I am told, was low down on the shore line.

I have recently been able to obtain from the same locality, but for the most part from a bed somewhat higher up in the series, further indications of the fish fauna of this period, of which I propose to give a very brief account in the following note.

The bed which contains the fish remains is a pale red calcareous sandstone with occasional pebbles in it. The weathered surface is crumbly and friable from the removal of the calcareous matter. All my specimens were obtained

from loose and weathered blocks, lying on the beach, and at the only place near which I found these blocks the cliff is rather high; and since the lower part is crumbly and unsafe, I could not climb up to trace the bed. Further along the coast I have been unable to find it, and therefore cannot tell its position in the series. The place where I found these blocks is about 200 yards to the west of the houses just beyond the large indentation in the coast formed by a little streamlet. I found, however, one scale of Bothriolepis in a bed of very fine dark red sandstone in situ, and low down on the coast line close under the Beach Hotel. In this stratum there were two thin layers of very fragmentary remains; this is, I believe, the bed reported on in the previous volume.

The remains found in the loose blocks are, as determined by Mr. A. Smith Woodward: (1) *Glyptopomus* scales; (2) *Bothriolepis*, probably portions of arm and plate with scales; (3) *Conchodus* tooth (probably); (4) *Ceraspis* scale (probably); (5) Rhizodont tooth and scale; (6) *Holoptychius* scale.

In addition to these there were numerous fragments which were too imperfect for Mr. Woodward to determine. Of these remains, perhaps the most interesting are *Glyptopomus* and *Conchodus*. In a letter on the subject of these remains, Mr. Woodward says: "I think you have discovered for the first time in England scales of Glyptopomus, and a fossil which seems to be a tooth of Conchodus." So far as the locality is concerned, I believe that all the genera, except Holoptychius, are new to Portishead.

I have pleasure in tendering my best thanks to Mr. Smith Woodward for his kindness in determining these specimens.

Some Notes on Ancient Mortars.

By ALFRED C. FRYER, Ph.D., M.A.

MORTAR has been defined as a mixture of slaked lime and sand in proper proportions, and when this mixture is spread in thin layers between stones or bricks it gradually hardens and acquires a considerable degree of tenacity, in a great measure from its gradual conversion into carbonate of lime, combining at the same time with the substance of the brick or stone. Although the mortar becomes sufficiently hard in a few days to bear considerable pressure, yet its maximum degree of hardness is not reached until the lapse of many years, and even centuries. Pliny tells us that the Romans prepared their mortars some time before they were used, and he further points out that the lime was slaked in pits and allowed to remain there for two or three years before it was actually required.

It was early discovered that lime reacts on certain bodies different from it in composition, especially when they were of a silicious nature. The ancients took advantage of this fact, and at an early period sand was employed to multiply the surface of contact, bring the whole of the hydrate of lime into active combination, as well with this as with the

surfaces of the stones or bricks, and prevent the lime from unduly shrinking as it hardens.

The best material is undoubtedly quartz sand, but not too fine. If the sand is very fine, the mortar becomes too dense to admit the air which is needful for its solidification; and if it be too coarse, the interstices become unduly large to be filled with the lime. A mixture of coarse and fine sand has been often employed, and angular sand has been much preferred to the smooth round sand.

Chemists have differed considerably on the cause of the setting of mortars, and from time to time various theories have been raised. At one time the hardening was considered due to mechanical agency, and now it is thought that chemical combination contributes to render it durable. This chemical action, says an author in a well-known book,[1] is not wholly confined to the formation of carbonate of lime. The action which takes place during the hardening of mortar appears to be somewhat as follows:—The carbonic acid of the atmosphere, acting upon the exposed parts of the mortar, forms a coating of calcium carbonate; the amount of this substance formed increases with the age of the mortar; but at no time, so far as we can learn, is the whole of the lime of the mortar converted into carbonate. Besides calcium carbonate there is also formed a small quantity of calcium silicate, by the action of the lime upon the silica of the sand and of the stone or brick; this silicate spreads over the surface of each little grain of sand, and binds the whole mass compactly together. The formation of the carbonate continues so long as the mortar retains moisture to dissolve the lime, and the air has access. Whatever may be the advantages gained from these combinations, they are not sufficient to impart firmness to the material; it is only from the

[1] "Chemistry as Applied to the Arts and Manufactures," vol. ii. p. 460.

combined influence of the adhesiveness of the mortar to the stone, rendered more intimate by chemical combination, that the full effects are obtained.

The greater proportion of ancient mortars are firm and durable, but this, however, is not the universal rule. An instance of a mortar of inferior quality came under my notice in 1888 when a mithræum was discovered accidentally at Ober-Florstadt. This was dug out at the desire of a gentleman residing at Darmstadt, and it was found to be a rectangle extending south to north. The interior space was occupied by a depression approached by a descent of four steps on the southern side. Several altars, figures, coins, etc., were found and were removed to the museum at Darmstadt. Professor Adamy made careful examination of the place, and came to the conclusion that the building was a temple dedicated to Mithras, and was built about the middle of the third century. I analysed a small piece of the mortar with the following result :—

	Per cent.
Sand, insoluble in hydrochloric acid	74·92
Carbonate of lime	5·09
Alumina and oxide of iron	8·61
Carbonate of magnesia	1·02
Sulphate of lime	0·52
Lime otherwise combined	1·50
Soluble silica	0·84
Moisture and chemically combined water	7·20
Chlorine	trace
Alkalies	trace

The carbonic acid present is not sufficient to completely account for the lime and magnesia, so that a portion of these must exist as hydrate, or more probably combined with silica. There was 0·84 per cent. of soluble silica in this

mortar. This is formed, according to Petzold, by the action of slaked lime on quartz sand, while according to Winkler it is due to the presence of alumina in the quicklime used for the mortar, and is formed when the limestone is burnt. Feichlinger, however, considers it quite possible that the formation of calcium silicate may take place at the point of contact between the mortar and the building stone.

In judging of a mortar, the relation of lime to sand is of importance. This relation varies according to the quality of the sand, for fine sand required less lime than coarse. In the mortar under consideration the sand was unusually coarse, and large pieces of quartz could easily be recognised. It has been estimated that a good lime-mortar should contain 15 per cent. of slaked lime in the dried mass. The amount of hydrated lime in the above is only a little over 7 per cent. The above remarks show that this ancient Roman mortar had very inferior properties. This is confirmed by the fact that it easily crumbles away. The percentage of alumina and ferric oxide appears to be high, but the quantity of magnesia is small.

I venture to bring before you the composition of some mortars used by the Romans in this country, and as an example I will take the mortar from beneath some tesselated pavement which was unearthed while excavating for the foundations of the new Guildhall at Gloucester during the summer of 1890. This mortar was fairly hard and thoroughly hydraulic, and when examined under the microscope was found to consist of a white, or rather a pink coloured matrix cementing together fragments of burnt clay (crushed bricks, tiles, or pottery) or pozzuolana of a bright red or reddish-brown colour and rounded grains of pure, colourless quartz sand very much resembling the standard cement testing sand from Leighton Buzzard, or some coarse

sea sands derived from quartz rocks. The matrix consisted almost entirely of carbonate of lime with a very small trace of hydrate of magnesia. When it was treated with very dilute hydrochloric acid there was left a porous, but very coherent skeleton of sand and burnt clay cemented together with calcium silicate, probably formed by the action of the caustic lime on the clay or pozzuolana, and which was readily decomposed by more concentrated acid. The following is the empirical analysis :—

	Per cent.
Lime (CaO)	11·20
Magnesia (MgO)	1·82
Alumina (Al_2O_3)	12·92
Oxide of iron (Fe_2O_3)	6·58
Silica (pure quartz sand) (SiO_2)	26·71
Combined silica (SiO_2)	21·04
Sulphuric anhydride (SO_3)	trace
Carbon dioxide (CO_2)	8·62
Water	10·60
Alkalies	·51

The water present was nearly all, if not all, hydroscopic, and was readily driven off. The rational composition of this and other ancient mortars can only be to a very great extent mere question of guesswork, and every one may have a different theory.

When the foundation for the new post office of St. Martin-le-Grand was dug, a fine portion of old London wall was discovered. This splendid piece of Roman work measured about 120 feet in length of solid blocks of Kentish Rag interstratified pretty regularly at every fifth course by a double, or near the top triple layers of red tiles, and bound together by a white mortar which for strength and endurance far surpassed that used in the present day. This

mortar was carefully examined by Mr. John Spiller, F.C.S., and he stated in his paper which appeared in the "Chemical News"[1] that the probable arrangement of the constituents might be considered:—

	Per cent.
Sand	45·95
Brick particles	0·53
Alumina	3·00
Peroxide of iron	0·48
Carbonate of lime	27·73
Silicate of lime	15·19
Sulphate of lime	0·63
Carbonate of magnesia	1·59
Water and loss	4·90

This mortar was originally made up of about three parts by weight of sand to one part of dry lime. In modern practice it is usual to employ more sand and less lime.

Mr. Spiller found that after extracting as much silica as possible by means of dilute hydrochloric acid that the residue yielded nearly 11 per cent. of silica to cold dilute sodium hydroxide. Under similar treatment with cold soda, builder's sand and pulverized flints yielded a mere trace of silica in solution, whilst mortars 20, 100 and many hundreds of years old yielded quantities of silica increasing with the age of the mortar. It was suggested by Mr. Spiller that perhaps the Romans used a pozzuolana in compounding their mortar, or perhaps this soluble silica, or silicate, is the direct result of long contact of plain sand and lime.

It is interesting to note that a sample of mortar from the square Roman bath at Bath contained fully as much soluble silica as the mortar from the Roman wall found in London.

The pozzuolana found in the neighbourhood of Puteoli,

[1] "Chemical News," 1888, p. 189.

near Naples, is the product of volcanic eruptions, and has this composition:—

	Per cent.
Silica	45·56
Alumina	14·24
Lime	8·94
Magnesia	3·90
Oxides of iron and titanium	11·02
Alkalies and volcanic substances	5·70
Water	10·64

However, it was not needful for the Romans to have brought a pozzuolana from Italy, for they had already found beds of trass near Bonn which have been worked ever since they first quarried them. Like pozzuolana it is of volcanic origin, and has doubtless been thrown out of the burning mountain of Eifel. The following is an analysis of a sample of trass:—

	Per cent.	
Silica	10·92	Soluble in acid.
Oxide of iron	11·29	
Manganese	trace	
Alumina	18·52	
Lime	3·81	
Magnesia	2·54	
Alkalies	3·01	
Silica	38·12	Insoluble in acid.
Alumina	0·92	
Oxide of iron	0·74	
Lime	2·81	
Magnesia	0·19	
Alkalies	1·05	
Water, with traces of ammonia	9·09	

In conclusion, it is interesting to note that Mr. W. B. Roberts[1] analysed some specimens of old mortar from the walls of a building erected about 200 years ago, and he

[1] "Chemical News," vol. 400, p. 25.

found considerable traces of hydrated silica. It occurred to Mr. Roberts that possibly the hardening or setting of mortar might be due to some chemical action occurring between the lime and the silica when these ingredients were mixed, whereby some proportion of the silica was caused to assume the gelatinous form. This being then incorporated by the usual mixing process, subsequently solidified, binding the whole bulk with a hard network of silica. A series of experiments were made, and the general conclusions arrived at may be summarized as follows :—

(1) Practically no gelatinization of silica occurs in the manufacture of mortar.

(2) Under the ordinary conditions of access of air the lime in mortars becomes gradually dehydrated, absorbs carbonic acid, and forms neutral carbonate.

(3) The absorption of carbonic acid is very slow.

(4) A slight action takes place between the lime and the silica, although very small.

(5) Although even the small proportion of dry silicates slightly increases the hardness of a mortar, the ordinarily sufficient hardness of mortar is obtained by simple dehydration and carbonation.

These conclusions appear to be confirmed by the fact that lime already containing a small proportion of carbonate is preferred to pure lime for making mortar.

Analysis of Volcanic Ashes from the Volcanic Eruption at Krakatoa in 1883.

By ALFRED C. FRYER, Ph.D., M.A., F.C.S.

SOME observers remark that the Krakatoa eruption yielded labradorite, augite, magnetite, and apatite. Others state that hornblende and iron pyrites were also found. The principal mass of the ashes consists of a glass crowded with minute cavities. The larger pieces readily floated on water. The glass is generally colourless, but more or less brown. Microliths were occasionally met with. The cavities in the glass were sometimes round, and sometimes drawn out in a longitudinal direction. In addition to the glass, many more or less perfect fragments of crystals were observed, consisting principally of plagioclase and bronzite, together with small and rather narrow prisms of a greenish mineral, probably augite, and apatite. It has been pointed out that this youngest eruption-product from the Straits of Sunda bears the andesite character so general in the district, and is of special interest on account of the presence of rhombic pyroxene.

A small quantity of the ashes which fell in Batavia was

sent to me. The specific gravity was 2·36, and its chemical composition was as follows :—

Silica ($Si O_2$)	65·92
Titanic oxide ($Ti O_2$)	0·40
Alumina ($Al_2 O_3$)	14·62
Ferric oxide ($Fe_2 O_3$)	4·20
Ferrous oxide (FeO)	2·68
Manganese monoxide (Mn O)	trace
Lime (Ca O)	3·12
Magnesia (Mg O)	0·92
Sodium oxide ($Na_2 O$)	4·32
Potassium monoxide ($K_2 O$)	1·20
Loss on ignition	2·52

Mild Steel.

By J. W. I. HARVEY.

Read before the Engineering Section.

MILD steel has been produced in comparatively limited quantities during the last thirty years (1862), and was originally employed in the construction of land boilers, although I believe more than one steamer was built of this material, to run the blockade at the time of the American War about the year 1862. But it is only within the last 15 or 17 years (1875), that it has been possible to introduce greater precision and certainty into the exact composition of the material.

Sir W. Siemens commenced his operations in 1862, and the Landore Steel Works at Swansea were established in 1869, but they were chiefly confined to the production of steel rails, tyres, and axles up to the year 1874. The first application to ship-building on an extensive scale was in 1876, when this Company, under the management of Mr. James Riley, supplied the steel for Her Majesty's despatch vessels *Iris* and *Mercury*, and so lately as 1878 the tonnage of shipping built of steel in this country did not exceed 4,500 tons.

The mild steel industry is one that has in the course of about twelve years grown from insignificance to one of the most important in Great Britain, and this material has practically supplanted iron for constructive purposes in that

comparatively short space of time. It is scarcely to be wondered at that this should be so, when it is remembered that as long as the material previously used was called iron, the test of nomenclature was about all the testing it received, and I have no hesitation in saying that an immense quantity of very inferior and unreliable material has been worked up into so-called iron structures, such as roofs, bridges, boilers, and ships, in consequence. But, as regards mild steel, matters are very different, for every charge is thoroughly and scientifically tested and analysed, and the results recorded, so that the mechanical and chemical properties of practically every plate and bar is known, and the engineer can, if he likes, get the exact quality of material which in his judgment is the most suitable for the purpose he has in view. No doubt the large amount of attention given to the quality of this material is in a great measure the secret of its success; and as the qualities of mild steel are now so accurately determined, it is universally adopted and preferred for those special purposes for which only the best Yorkshire iron could formerly be used.

In contradistinction to the rough-and-ready way in which merchant iron was and still is manufactured and branded, generally without any testing or analysing, all the manufacturers of mild steel find it necessary, as almost the first step in the process, to provide a very efficient and complete laboratory and mechanical testing house, with a large staff of highly qualified chemists and testing surveyors, specially devoted to the careful selection of the raw materials, and for testing the steel during the process of manufacture.

I am informed that all steel manufactured is subject to the most minute analysis and testing by the manufacturer's staff as a commercial every-day precaution, whether it may

have to pass a further public survey or not; and in the case of nearly all large contracts for steel, the material is still further subject to the tests laid down by the Board of Trade, the Admiralty, Lloyd's Committee, or the purchaser's own surveyors and experts, and thus the constructor is enabled to place almost absolute reliance upon the quality of his material, and in consequence it has been stated on the best authority (Mr. Samuel Adamson), that whereas in the old days when using wrought iron the return of bad plates to the makers was at the rate of 12 %, that now with steel the returns do not exceed 0·25 %.

The mild steel now so much in use contains, on the average, 99 % iron, 0·15 % carbon, 0·63 % manganese, 0·03 % silicon, 0·06 % sulphur, and 0·06 % phosphorus, and each of these constituents has a special effect upon the temper and quality of the steel.

The presence of carbon within certain limits has the effect of reducing the malleability and ductility of the steel, and increasing the tenacity. It also imparts the property of hardening and tempering, when after being heated the steel is suddenly quenched in cold water. This latter quality of tempering is generally understood to mark the difference between iron and steel.

Thus the hardest steel found in commerce and used for razors and tools required to cut chilled rolls and such-like hard materials has as much as 1·5 % of carbon, with an ultimate tensile strength of 60 tons and an elastic limit of 30 tons, and owing to its brittleness and want of ductility is not adapted to constructive purposes.

On the other hand, steel used in shipbuilding, boiler-making, etc., contains only from 0·15 % to 0·20 % of carbon, and has an ultimate tensile strength of from 24 to 32 tons, with from 16 % to 25 % extension in 10 inches; whilst inter-

mediate between these limits lie steels of various tempers, that for bridge-building having from 0·30 % to 0·35 % of carbon, with an ultimate tenacity of from 27 to 31 tons, with 30 % contraction of fractured area, and that for rails and tyres having from 0·40 % to 0·50 % of carbon. Beyond this temper lie the different cast steels which are beyond the scope of this paper.

It is very desirable that the material should not contain a greater percentage of carbon than that stated above. An excess of carbon has the effect of rendering the steel capable of taking a temper, which property, whilst tending to increase its tenacity, also renders the material less ductile or elastic; and as the steel during its application might be subject to such conditions as would cause it to take a temper and so alter its properties, it is imperative that the percentage of carbon should be kept within such limits as will preclude any possibility of this tempering taking place.

I have already alluded to the universal practice of exhaustively testing this material, a practice I believe which is the very essence of the success attending the use of "mild steel," securing as it does most reliable data for determining the proportions necessary to secure safety with economy of material, or, commercially speaking, getting the most value for one's money.

To Mr. David Kirkcaldy we are indebted for very exhaustive tables of the results of tests of almost every conceivable description, on plates, plain, punched, drilled, and rivetted joints, bars of all descriptions, rivets, plain and corrugated furnaces, boxes representing combustion chambers of boilers, and a host of other forms, conducted by him at the instance principally of the Admiralty, the Board of Trade, the Committee of Lloyd's Register, and most of the large firms of steel makers and steel users in this and other countries.

The following table is very instructive as showing at a glance the superiority of steel over iron plates. The ultimate stress of the steel plates is about 36% greater than the mean of the iron plates, and the contraction of area at fracture which is a measure of the ductility largely exceeds that of the various irons, being 49·1% for the steel, against 20·6%, 13·07%, 5·4% for the iron plates respectively. It will therefore at once be seen how this property renders "mild steel" a much safer material to use than iron, especially in structures where it may be subject to suddenly increased strains, since the steel will by its extension and distortion call attention to the fact of its being overstrained long before the point of actual fracture has been reached. Again, the ultimate stress and contraction of area at fracture crosswise is considerably less than lengthways in the iron plates; this is not the case to so great an extent with the steel plates, the ultimate stress of the steel in both directions being almost identical, and the ductility crossways is not much less than lengthways.

Description.	Thickness of Plates.	Lengthways.			Crossways.		
		Mean Ultimate Stress per sq. inch.	Mean Contraction of Area at Fracture.	Mean Ultimate Extension in 10 ins.	Mean Ultimate Stress per sq. inch.	Mean Contraction of Area at Fracture.	Mean Ultimate Extension in 10 ins.
	Inch.	Tons.	Per cent.	Per cent.	Tons.	Per cent.	Per cent.
Iron Ship Plates .	$\frac{1}{4}, \frac{1}{2}, \frac{3}{4}$	22·01	5·4	5·7			
Iron Boiler Plates, ordinary quality	$\frac{1}{2}, \frac{3}{4}, 1$	21·15	13·07	9·6	18·48	4·41	3·2
Yorkshire Iron Plates	$\frac{3}{8}, \frac{1}{2}, \frac{5}{8}$	21·3	20·6	16·7	20·3	14·7	11·2
Steel Plates made by Steel Co. of Scotland . . .	$\frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1$	29·3	49·1	28·2	29·2	40 3	25·5

(Kirkcaldy.)

The "elastic stress" or the "elastic limit" of iron and steel has never, as far as I can ascertain, been very satisfactorily determined, probably from the fact that it has never been defined what particular property the term actually signifies.

Mr. Kirkcaldy defines the "elastic stress" to be what I may call the stress at which the material changes from the "passive" to the "active state of distress"; and this is illustrated by the results of some tests of mild steel, in which he found that after a tensile stress of 5 tons per sq. inch had been applied, the extension increased by equal increments of length for every 2,000 lbs. increment of stress up to 16 tons. At this point the increment of extension suddenly increased in a much more rapid ratio per increment of stress up to the ultimate stress, showing that the material has at that point passed its normal state of elasticity, and that at 90% of the ultimate stress the extension was only $\frac{2}{3}$ of the ultimate extension, the remaining one-third of the extension being accomplished during the application of the last 10% of the ultimate stress. This point appears to me to fix the position of the "elastic limit" more satisfactorily than any definition that has been previously suggested.

Until a few years ago I think I may venture to say that wrought iron held the first place amongst constructive materials; it was the engineer's best friend, upon it he relied with considerable confidence in the production of his greatest works. It has sustained that confidence well, notwithstanding its many defects, for which I fear that "arch enemy" to perfection, the "greed of gain," is mainly responsible; but the advance of science, not now content with the old rate of progress, but forging ahead with leaps and bounds, has brought into use the mild steel of which I have been speaking, and to which I think we must all agree to

give the first place by reason of the many advantages it possesses over wrought iron.

Mild steel is capable of being manufactured with almost absolute certainty in correspondence with any analysis within its range, and in such large quantities that great uniformity of composition is attained. Having been in a state of complete fusion, it is homogeneous, free from laminations and blisters, and has no entangled slag in it, which was far from being the case with iron, so that for boiler furnaces and the like the above characteristics render steel by far the most suitable material. Moreover, the plates being thinner are better conductors of heat. Steel plates can be produced of much larger size than iron plates without the same risks of being defective, and consequently there are required fewer seams and joints, which is a great advantage, particularly when thick plates are employed.

It is practically of equal tenacity in every direction, and when worked by experienced men is less liable to crack or injury when being flanged. Although my experience with steel is limited to boilers of comparatively recent construction, I believe this material is not subject to "pitting" to anything like the extent we have been accustomed to in iron boilers, which no doubt is due to the absence of slag and other impurities, which are found to exist to a very considerable extent in all iron plates, especially those of inferior manufacture, or when the heat used for "pile" has been insufficient to render the cinder perfectly fluid. In this connection I may mention that it has been stated that steel stays in the steam space, and steel plates subject to the action of water leaks under pressure, corrode far more rapidly than do those of iron; whilst on the other hand it is claimed for the steel that scale or dirt does not adhere so firmly as with iron, and that the comparatively pure water

from surface condensers does not affect it to the same extent. My theory is that the steel being the softer material is more readily attacked by the mechanical action of the steam bubbles and water leaks, and on the other hand being of a more uniform character is not so readily attacked by the condensed water, the surfaces remaining smoother for a longer time, so that the scale and dirt does not so easily adhere to them as it does to the rougher iron plates. In constructions of iron and steel of equal strength there is a saving of about 20% in weight in favour of the steel, but owing to its greater elasticity its deflection under a given load is considerably more than in the case of iron, and where this excess of deflection is inconvenient or dangerous it is necessary to provide additional stiffening. I am of opinion that in a good many steel structures every advantage has been taken of the tenacity of the material, and that the question of stiffness or resistance to buckling has been overlooked or neglected altogether. The advantage of mild steel over iron has perhaps been best illustrated in connection with the shipbuilding industry, where on account of its superior tenacity the scantlings have been reduced by 20%, and its elasticity affords greater security in the case of strandings, as the plates and framing will sustain a very considerable amount of bulging and buckling before fracture.

It is very doubtful whether or not the triple expansion engine would have been the success it is without the introduction of mild steel. In one point only is it inferior to iron. Although it is frequently welded, the welds are unreliable, and are only employed in compression, and even then are better if fitted with a covering plate. But this defect being known can be guarded against, and any risk compensated for.

SUMMARY OF PAPER

ON

"Acid Pumps."

READ BY WILLIAM THOMSON.
before the Engineering Section, Feb. 23rd, 1892.

THE various forms of apparatus required for the pumping of corrosive liquids, chiefly sulphuric and hydrochloric acids, were described and illustrated by diagrams.

For sulphuric acid the materials used are glass, stoneware, rubber, ebonite, lead, and iron; while for hydrochloric acid, glass, stoneware, rubber, gutta-percha, ebonite, wood, and siliceous freestone are employed.

When pumps are not available, the acid is raised manually or mechanically in carboys.

The following pumps were described and illustrated by diagrams—the hand pump, the steam injector, the plunger pump, Schlötter's pump, the diaphragm pump, the box pump, the acid egg, and the automatic acid egg.

Reports of Meetings.

GENERAL.

IN the 30th Annual Session, which has just ended, there have been eight General Meetings of the Society, all held at University College.

On Thursday, October 1st, 1891, Mr. H. A. Francis, F.R.M.S., read a paper on "The Mud Wasp" (*Odynerus Spinipes*), and its nest. Specimens of this insect, and also of the nest, were exhibited. (This paper is published in the December number of the *Field Club.*)

On Thursday, November 5th, Mr. Geo. Munro Smith, M.R.C.S., L.R.C.P., read a paper, entitled "The Physiological Aspects of Melancholy."

On Thursday, December 3rd, Mr. H. A. Garratt read a paper, entitled "The Construction of Locks." His remarks were amply illustrated by diagrams and specimens.

The Meeting held on January 7th, 1892, was devoted to the exhibition and discussion of various curiosities:—

Mr. Henry Charbonnier exhibited stuffed specimens of the bittern, great crested grebe, quail, and purple sandpiper.

Miss Fry showed a string of candlenuts, such as are used by the natives of South Africa for illuminating purposes.

Mr. G. C. Griffiths exhibited cases containing Lepidop-

tera of the sub-families Morphinæ and Nymphalinæ, and a gyandromorphous specimen of Eronia Hippia var. gæa.

Mr. Percy Leonard exhibited a live specimen of a singing mouse.

Dr. John A. Norton exhibited a collection of the eggs of British falcons and owls, and a series of abnormal eggs.

Mr. Robert Prideaux exhibited specimens of such Lepidoptera of the district as are liable to variation.

Mr. R. V. Sherring showed a number of photographs, being botanical studies taken at and near the Crater Lakes of Grand Etand and Lake Antoine, and views of the Island of Grenada.

At the Meeting held on February 4th, the late Dr. G. F. Burder, F.R.Met.Soc., read a paper on "Rainfall and Floods." This paper will be found printed in the Proceedings.

On March 3rd, Mr. C. E. Boucher, B.Sc., read a paper on "The Physiology of Germination." He illustrated his remarks by coloured diagrams.

On April 7th, Mr. F. R. Barrell, M.A., read a paper "On the Construction and Use of Calculating Instruments and Machines." A number of instruments and appliances for measuring were on exhibition, and their working was explained.

The 30th Annual Meeting was held on May 5th, and after the Report of the Council, the Balance Sheet and the Financial Report had been read and adopted, and the officers for the ensuing year had been appointed, Prof. C. Lloyd Morgan delivered his Presidential Address on "The Physical History of the Mendips." A number of photographs and maps were thrown on the screen.

H. PERCY LEONARD,

Hon. Reporting Secretary.

BIOLOGICAL SECTION.

AT the Monthly Meetings held between October and April, Dr. Francis H. Edgworth gave a paper "On the Sensory Nerves of the Thoracic and Abdominal Organs in Mammals" in relation to some recent advances in our knowledge of the subject.

The President exhibited and discoursed on "Odontophores (*Radulæ*) of the genera Helix, Limax, Testacella, Patella, Chiton, Trochus, Nassa, and other gasteropods.

Mr. Robert Prideaux explained the life-history of the Clematis Emerald Moth (*Iodos vernaria*), and Mr. C. King Rudge exhibited some Echini and Starfishes, and drew attention to their main structural features.

In field botany the most noteworthy event in connection with the Bristol Flora has been the discovery on Brandon Hill, by Mr. David Fry, of *Trigonella* (*Falcatula*) *ornithopodioides*, a plant anciently reported to grow near the city, but which is not known to have been observed in the district by any living botanist. Its presence in such a spot is of interest from several points of view.

JAS. W. WHITE, F.L.S.

CHEMICAL AND PHYSICAL SECTION.

DURING the past Session four Meetings have been held, at which papers were read as follows:—

Nov. 12. "What is a Wave?" by Mr. E. G. Crawford.

Dec. 15. "The Spark Discharge," by Dr. E. H. Cook. Preparation of Nickel Carbonyl, and exhibition of glass blowing with the oxyhydrogen blowpipe, by the President.

Feb. 23. "Corresponding Conditions of Matter," Prof. S. Young.

March 29. Exhibition of Glycerine Crystals, by Mr. W. M. Roscoe. Di-Electric Strength of Air, Mr. D. Rintoul.

ARTHUR RICHARDSON, *Hon. Sec.*

ENGINEERING SECTION.

FIVE Meetings were held during the Session 1891–2. The following papers were read:—"Metal Sleepers on Light Railways and Tramroads," Mr. Thomas Morgan; "Reversing Valve-gears," Mr. H. A. Garratt; "Siemens-Martin Steel," Mr. J. W. I. Harvey; "Acid Pumps," Mr. W. Thomson; "Refuse Destructors," Mr. T. J. Moss Flower.

An Excursion to parts of the Bristol Water Works took place on Wednesday, July 8th, 1891. The party, which numbered about 30, and included as guests Professor C. Lloyd Morgan and Professor A. Leipner, left Bristol at 11 a.m., and drove to Barrow. After inspecting the Barrow reservoir and filter-beds, the journey was resumed to Chew Magna compensation reservoirs. After lunch at Chew Magna, the Sherborne reservoir was visited, and thereafter the party returned to Chew, where dinner was served at 6. The start home was made at 7.30, and Bristol was reached at about 9.

Mr. H. W. Pearson, M.I.C.E., engineer to the Water Company, kindly conducted the party, and pointed out and explained the features of interest.

NICHOLAS WATTS, *Hon. Sec.*

ENTOMOLOGICAL SECTION REPORT, 1891–2.

ONLY one excursion was taken by the Section during the excessively wet season of 1891, in June to Dursley, and was very successful from an entomological point of view, a large number of species being captured, among which might be named *N. Lucina*, *A. Trifolii*, *D. Unguicula* in great abundance, *B. Pandalis*, etc.

The usual indoor Meetings of the Section have been held, and a large number of important and interesting species, both British and foreign, have been exhibited; but no papers requiring record have been read.

GEO. HARDING, *Hon. Sec.*

GEOLOGICAL SECTION.

AN excursion was made to Pyle Hill. The members met at the Bristol Museum, where Mr. Edward Wilson, F.G.S., exhibited diagrams and fossils, and explained the nature and sequence of the Rhœtic or Penarth beds at the Pyle Hill cutting. The party then proceeded to the cutting, and examined the beds *in situ*.

A second excursion was made to Shepton Mallet, when the Lias quarry near the G.W.R. station was examined, and subsequently the so-called "bastard freestone" resting immediately on the Mountain Limestone. Here *Pecten pullus* and other Lower Lias fossils were found.

Two Meetings were held. At the first the President of the Section exhibited and made explanatory remarks upon the different forms of Silica as they occur in the rocks. At the second Mr. Gardener exhibited and described the fish scales found by him near Portishead, of which some account has been given on a previous page.

CHARLES JECKS,
Acting Hon. Sec.

The following Publications of the Bristol Naturalists' Society may be obtained from any Bookseller, or from the Honorary Secretary.

One Volume, bound, 5s.

FLORA OF BRISTOL.

By James Walter White, F.L.S.

The area of this flora is that included in the geological map of the Bristol coal field, by the late William Sanders, F.R.S., F.G.S.

The Fungi of the Bristol District. By Cedric Bucknall, Mus. Bac.

Part IV.	Species 690 to 836. 4 plates, 3 coloured, 1 black.	1*s.* 6*d.*
,, V.	,, 837 to 934. 2 ,, 1 ,,	1*s.*
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,, VII.	,, 1024 to 1084.	6*d.*
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,, XI.	,, 1322 to 1362.	6*d.*
,, XII.	,, 1363 to 1399. 2 plates	1*s.*
,, XIII.	,, 1400 to 1431	
Index to Parts I. to XIII. and plates		1*s.*

On the Newly-Discovered Phenomenon of Apospory in Ferns. By Charles T. Druery, F.L.S. Illustrated. 1*s.*

Contributions to the Geology of the Avon Basin. By Prof. Lloyd Morgan, F.G.S. I. "Sub-Aerial Denudation and the Avon Gorge." Coloured Map. II. "The Millstone Grit at Long Ashton, Somerset." With Map. 1*s.*

III. "The Portbury and Clapton District." IV. "On the Geology of Portishead." 2 coloured maps and 2 plates. 1*s.* 6*d.*

Sleep and Dreams. By George Munro Smith, L.R.C.P. Lond., M.R.C.S. 2 plates. 1*s.*

The Bone-Cave or Fissure of Durdham Down. By E. Wilson, F.G.S., Curator of the Bristol Museum. 2 plates. 1*s.*

Notes on a Common Fin Whale, lately stranded in the Bristol Channel. By E. Wilson, F.G.S., Curator of the Bristol Museum. Photograph. 1*s.*

The Severn Tunnel. By Charles Richardson, C.E., and Notes on the Geology of the Section by Prof. C. Lloyd Morgan, F.G.S., Assoc. R.S.M. With geologically coloured Section of Tunnel, map and plate. 2*s.*

The Mendips: A Geological Reverie. By Prof. C. Lloyd Morgan, F.G.S., Assoc. R.S.M. 1*s.*

The Arch. By Charles Richardson, C.E., with illustrations. 1*s.*

Portrait and Obituary Notice of the first President of the Society, Mr. William Sanders, F.R.S. 6*d.*

Portrait and Memoir of the second President of the Society, Henry Edward Fripp, M.D., M.R.C.P. 6*d.*

Proceedings, New Series.

Vol. I., Part 1, 1873–74.	4*s.*	Vol. IV., Part 1, 1882–83.	3*s.* 6*d.*
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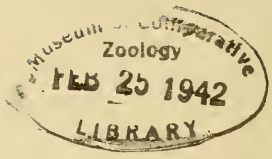

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George Forster Burder,

M.D., F.R.C.P.

Obituary from "British Medical Journal."

(No. 1626, February 27, 1892.)

GEORGE FORSTER BURDER was born at Stroud in 1824. He was the son of the Rev. John Burder, a Nonconformist minister, and grandson of the Rev. George Burder, also a somewhat noted Nonconformist minister, and the author of *Village Sermons*, etc. He received his medical education at University College, London; in 1850 he obtained the diploma of M.R.C.S.; in 1851 that of L.S.A., and the degree of M.D. of King's College, Aberdeen; in 1859 he was made a Member, and in 1875 a Fellow of the Royal College of Physicians.

He settled in practice in Clifton, and in 1856 was appointed physician to the Bristol General Hospital, a post which he held until 1883, when, after twenty-seven years of active service, he was made consulting physician to the hospital. For twenty-three years he held the Lectureship on Materia Medica and Therapeutics at the Bristol Medical School, and for the last seventeen years of this period acted as honorary secretary to the school; both these positions he resigned in 1879.

Dr. Burder was President of the Bristol Medico-Chirurgical Society for the session 1884–85, and of the Bath and Bristol Branch of the British Medical Association for the year 1887–

88. Both of his presidential addresses treated in a masterly manner certain of the problems connected with the "germ theory" of disease, to which he was an early convert.

For some years Dr. Burder had suffered from anginal symptoms, which had increased in severity of late, and on the evening of February 6th he died suddenly from syncope.

Dr. Burder was an able, clear-sighted, scientific physician, and an excellent therapeutist, and enjoyed the complete confidence of his patients. He had also a high reputation in scientific subjects outside his own profession. He was widely known as a distinguished meteorologist, and was the regular contributor of valuable communications on the meteorology of the district. Only two days before his death he read before the Bristol Naturalists' Society an able paper on "Rainfall and Floods." He was a Fellow of the Royal Meteorological Society and of the Scottish Meteorological Society.

A thoroughly clear, logical thinker, and endowed with sound common sense, Dr. Burder possessed as a speaker the rare power of expressing his thoughts in forcible, well-chosen language. As a man, he was very highly esteemed for his signal uprightness and integrity of character. Kindly and genial in his manner and a favourite with all, by those who knew him best he was beloved in no common degree.

From Annual Report
of the Council of the Bristol Naturalists' Society, 1892.

George Forster Burder, M.D., F.R.Met.Soc., whose wide and scientific knowledge, whose clear and weighty judgment, whose ever-ready help, and whose unfailing kindliness and courtesy made him an honour to our Society, and a valued Colleague on its Council, became a member of the Society at its formation, in April, 1862. He was most constant in his

attendance at the meetings, and not only prepared for more than twenty years "Reports on the Rainfall in Clifton" for the Society's publications, but also contributed the following important papers:—

Feb. 1st, 1872. "A Puzzle in Rain, and how to solve it."

March 4th, 1880. "Recent Investigations on the Course of Storms."

April 6th, 1882. "On Decrease of Rain with Elevation."

Feb. 1st, 1883. "Thirty Years' Rainfall in Clifton."

Oct. 9th, 1884. "Peculiar Phenomena during the Eclipse of the Moon on Oct. 4th, 1884."

March 3rd, 1887. "The History of the Potato—in connection with the Tercentenary of its Introduction into Europe."

May 3rd, 1888. "The Illumination of the Eclipsed Moon."

Feb. 4th, 1892. "Rainfall and Floods."

His interest in the Society, and his various labours for it, could not fail to be generally recognised, and, accordingly, after having filled for two years the office of Hon. Reporting Secretary, he was elected for seven consecutive years (1873–80) one of the two Vice-Presidents, and after the death of the then President, Dr. Hy. Fripp, in March, 1880, was chosen President, which post he held till 1883.

Phenological Observations for 1892.

PLANTS.

Recorders: Miss Annie Baker, Bridgwater (A.B.); Mr. Lewis W. Rogers, Clifton (L.W.R.).

Abbreviations.—App., first appearance above ground; Bud b., first buds bursting; Fol., almost in foliage; Fl., first flower; R. fr., first ripe fruit.

1. *Anemone nemorosa* (Wood Anemone).—Fl. March 26th, Combe Dingle, L.W.R.

2. *Ranunculus ficaria* (Pilewort, Lesser Celandine).—Fl. March 18th, Road to Combe Dingle, L.W.R.; Feb. 12th, Rhode Lane (this does not apply to anthers bursting), A.B.

3. *Ranunculus acris* (Upright Crowfoot).—App. March 18th, Road to Combe Dingle, L.W.R.; Fl. May 19th, Sneyd Park, L.W.R.; April 18th, Hamp, A.B.

4. *Caltha palustris* (Marsh Marigold).—App. March 19th, by 10th, Durleigh, A.B.; Fl. April 7th, Durleigh (this does not apply to anthers bursting), A.B.

5. *Papaver rhœas* (Red Poppy).—Fl. June 11th, by 4th, Hamp, A.B.

6. *Nasturtium officinale* (Watercress).—Fl. June 5th, Pensford, L.W.R.

7. *Cardamine pratensis* (Cuckoo-Flower).—Fl. April 23rd, Pill, L.W.R.; May 3rd, by 2nd, A.B.

8. *Alliaria officinalis* (Jack-by-the-hedge).—Fl. April 23rd, Shirehampton, L.W.R.

9. *Draba verna* (Whitlow Grass).—App. Jan. 27th, Gully, L.W.R.; Fl. Feb. 24th, Gully, L.W.R.; observed by a friend three weeks earlier.

10. *Viola odorata* (Sweet Violet).—Fl. March 30th (white), L.W.R.

11. *Polygala vulgaris* (Milkwort).—Fl. May 20th, Gully, L.W.R.

12. *Lychnis diurna* (Red Campion).—Fl. May 7th, Stoke Bishop (females very rare), L.W.R.; May 6th, by 1st, Rhode Lane, A.B.

13. *Stellaria holostea* (Greater Stitchwort).—Fl. April 9th, Pill Road, L.W.R.; Fl. April 2nd, Hamp, A.B.

14. *Cerastium pumilum* (Mouse-ear).—Fl. March 20th, Gully, L.W.R.; Fl. March 19th, Durleigh, A.B.

15. *Malva sylvestris* (Common Mallow).—App. Jan. 25th, by 5th, Hamp, A.B.; Fl. June 5th, Clutton, L.W.R.; June 2nd, by 2nd, Hamp, A.B.

16. *Tilia parvifolia* (Small-leaved Lime).—Bud b. April 7th, Whiteladies Road, L.W.R.; Fol. May 12th, same place, L.W.R.; Fl. June 28th, same place, L.W.R.

17. *Hypericum perforatum* (Perforate St. John's Wort).—Fl. June 25th, under Sea Wall, L.W.R.; July 14th, by 3rd, Rhode Lane, A.B.

18. *Hypericum pulchrum* (Upright St. John's Wort).—Fl. not seen this year, though carefully looked for, L.W.R.

19. *Geranium Robertianum* (Herb Robert).—App. Jan. 25th, by 8th, Hamp, A.B.; Fl. May 7th, Stoke Bishop, L.W.R.; May 11th, Hamp, A.B.

20. *Euonymus Europæus* (Spindle-tree).—Bud b. March 4th, near Zoo; May 12th, Proctor's Fountain, in Fl. bud; Fl. May 28th, same place; R. fr. purple by Oct. 4th, bursting pods Oct. 28th, L.W.R.

21. *Acer pseudo-platanus* (Sycamore).—Bud b. March 27th, Proctor's Fountain, L.W.R.; April 2nd, Bridgwater, A.B.

22. *Æsculus hippocastanum* (Horse Chestnut).—Bud b. April 2nd, Combe Dingle and Leigh Woods, L.W.R.; April 2nd, Hamp, A.B.; Fol. April 26th, Sneyd Park, L.W.R.; April 30th, Hamp, A.B.; Fl. May 16th, Sneyd Park, L.W.R. The same tree I have noted for three years, this year it did not bear any blossom, A.B.

23. *Cytisus laburnum* (Laburnum).—Bud b. March 20th, Apsley Road, L.W.R.; April 2nd, Wembdon, A.B.; Fol. May 10th, Apsley Road, L.W.R.; Fl. May 16th, Apsley Road, L.W.R.; May 18th, by 1st, Wembdon, A.B.; R. fr. Sept. 1st, Apsley Road, L.W.R.

24. *Trifolium repens* (Dutch or White Clover).—Fl. June 4th, Temple Cloud, L.W.R.; May 23rd, Durleigh, nearly in flower, A.B.

25. *Lotus corniculatus* (Bird's-foot Trefoil).—Fl. April 26th, under Sea Wall, L.W.R.; May 21st, Hamp (may have been two days before), A.B.

26. *Vicia cracca* (Tufted Vetch).—Fl. June 18th, Westbury, L.W.R.; R. fr. Aug. 26th, Sea Mills, L.W.R.

27. *Vicia sepium* (Bush Vetch).—Fl. April 23rd, Shirehampton, L.W.R.; April 7th, Rhode Lane, A.B.; R. fr. June 25th, under Sea Wall, L.W.R.

28. *Lathyrus pratensis* (Meadow Vetchling).—Fl. June 13th, Ashley Hill, L.W.R.; June 9th, by 4th, Durleigh Road.

29. *Prunus spinosa* (Sloe, or Blackthorn).—Bud b. April 15th, Sea Mills, L.W.R.; April 2nd, Rhode Lane, A.B.; Fol. April 22nd,

Gully, L.W.R.; April 13th, Hamp, A.B.; Fl. April 6th, Gully, L.W.R.; April 7th, by 4th, Rhode Lane, A.B.; R. fr. August 20th, Sedgmoor, A.B.

30. *Spiræa ulmaria* (Meadow Sweet).—Full fol. May 14th, Keynsham; Fl. June 25th, Boiling Well, L.W.R.

31. *Potentilla anserina* (Silver-weed).—App. April 15th, Combe Down, L.W.R.; April 4th, by 5th, Hamp, A.B.; Fl. May 14th, Hanham, L.W.R.

32. *Rosa canina* (Dog Rose).—Bud b. March 18th, Combe Dingle, L.W.R.; March 19th, by 4th, Durleigh, A.B.; Fol. April 15th, Combe Dingle, L.W.R.; April 11th, Hamp, A.B.; Fl. June 3rd, Sea Mills, L.W.R.; Fl. June 2nd, Rhode Lane, A.B.; R. fr. Sept. 26th, Downs, L.W.R.; Sept. 15th, Hamp, A.B.

33. *Pyrus aucuparia* (Mountain Ash, or Rowan).—Bud b. April 14th, Osborne Road, L.W.R.; April 2nd, Wembdon, A.B.; Fol. May 10th, Whiteladies, L.W.R.; April 30th, Wembdon, A.B.; Fl. May 16th, Whiteladies, L.W.R.; May 18th, Wembdon, A.B.; R. fr. July 27th, Whiteladies, L.W.R.; August 12th, North Field, Wembdon, A.B.

34. *Pyrus aria* (White-beam).—Bud b. April 15th, Combe Dingle, L.W.R.; Fol. May 8th, Clifton Down, L.W.R.; Fl. May 24th, Leigh Woods, L.W.R.

35. *Cratægus oxyacantha* (Hawthorn).—Bud b. March 27th, near Zoo, L.W.R.; March 12th, Taunton Road, A.B.; Fol. April 16th, Downs, L.W.R.; April 11th, Hamp, A.B.; Fl. May 12th, L.W.R.; May 13th, by 1st, Rhode Lane, A.B.; R. fr. August 26th, Downs, L.W.R.

36. *Epilobium hirsutum* (Great Hairy Willow-herb).—App. May 14th, Hanham, L.W.R.; Fl. July 18th, Sea Mills, L.W.R.; July 14th, by 3rd, Rhode Lane, A.B.

37. *Epilobium montanum* (Broad Willow-herb).—App. April 23rd, King's Parade, L.W.R.; Fl. May 14th, King's Parade, L.W.R.; July 22nd, by 4th, Canal, A.B.; R. fr. by August 10th, Whatley Road, L.W.R.

38. *Angelica sylvestris* (Wild Angelica).—App. June 3rd, under Sea Wall, L.W.R.; June 11th, Hamp, A.B.; R. fr. Aug. 1st, Sea Mills, L.W.R.

39. *Daucus carota* (Wild Carrot).—App. June 25th, under Sea Wall, L.W.R.; July 22nd, by 6th, Canal, A.B.

40. *Hedera helix* (Ivy).—Fl. Sept. 1st, Gully, L.W.R.; Fr. Dec. 30th, berries still quite green, L.W.R.

41. *Cornus sanguinea* (Dog-wood). — Bud b. April 6th, Gully, L.W.R.; Fol. April 22nd, Gully, L.W.R.; May 13th, Hamp, A.B.;

Fl. June 10th, Gully, L.W.R.; June 9th, Wembdon Road, A.B.; R. fr. August 30th, L.W.R.

42. *Adoxa moschatellina* (Moschatel).—App. March 26th, Combe Dingle, L.W.R.; Fl. April 2nd, Combe Dingle, L.W.R.

43. *Syringa vulgaris* (Lilac).—Bud b. Feb. 10th, Bridgwater, A.B.; Fol. April 10th, Pembroke Road, L.W.R.; April 11th, Bridgwater, A.B.; Fl. May 7th, Osborne Road, L.W.R.; May 13th, Bridgwater, A.B.

44. *Galium aparine* (Cleavers).—App. May 7th, Stoke Bishop, L.W.R.; Fl. May 27th, opposite Sea Mills, L.W.R.; May 23rd, by 1st, Wembdon, A.B.

45. *Galium verum* (Yellow Bedstraw).—Fl. June 28th, under Sea Wall, L.W.R.

46. *Dipsacus sylvestris* (Wild Teasel).—Fl. Aug. 1st, Sea Mills, L.W.R.; July 25th, by 3rd, A.B.

47. *Scabiosa succisa* (Devil's bit).—Fl. Aug. 10th, opposite Sea Mills, L.W.R.

48. *Petasites vulgaris* (Butter-bur).—Fl. Jan. 25th, by 4th, Hamp, A.B.

49. *Petasites fragrans*.—Fl. Nov. 23rd, under Sea Wall, with Fol., L.W.R.

50. *Tussilago farfara* (Coltsfoot).—Fl. March 5th, under Sea Wall, L.W.R.; Fol. by June many places, L.W.R.

51. *Achillea millifolium* (Yarrow).—App. March 19th, by 8th, Hamp, A.B.; Fl. June 29th, Westbury, L.W.R.; July 13th, by 2nd, Rhode Lane, A.B.

52. *Chrysanthemum leucanthemum* (Ox-eye).—App. March 8th, Combe Down, L.W.R.; Fl. May 16th, Sea Wall, L.W.R.; June 10th, by 8th, Canal, Bridgwater, A.B.

53. *Artemisia vulgaris* (Mugwort).—Fl. Aug. 1st, Sea Mills, L.W.R.

54. *Senecio Jacobæa* (Ragwort).—Fl. July 8th, Stapleton Road, L.W.R.; July 25th, by 6th, Petherton Levels, A.B.

55. *Centaurea nigra*.—Fl. July 15th, Leigh Woods, L.W.R.

56. *Carduus lanceolatus* (Spear Thistle).—July 12th, Redland Hall Yard, L.W.R.

57. *Carduus arvensis* (Field Thistle).—July 13th, Markham Bottom, L.W.R.

58. *Sonchus arvensis* (Corn Sow Thistle).—Fl. July 16th, Sneyd, L.W.R.

59. *Hieracium pilosella* (Mouse-ear Hawkweed).—Fl. May 27th, Gully, L.W.R.

60. *Campanula rotundifolia* (Hairbell).—Fl. July 17th, Gully, L.W.R. ; June 24th, Bridgwater, A.B.

61. *Ligustrum vulgare* (Privet).—Fl. June 10th, Gully, L.W.R. ; June 9th, Durleigh, A.B.

62. *Convolvulus sepium* (Greater Bindweed). — Fl. July 10th, King's Parade, L.W.R. ; May 25th, by 2nd, Durleigh, A.B.

63. *Symphytum officinale* (Comfrey).—Fl. May 14th, Clifton Down, anthers burst by 26th, L.W.R.

64. *Pedicularis sylvatica* (Red Rattle).—Fl. May 17th, Markham Bottom, Prof. Leipner.

65. *Veronica Chamœdrys* (Germander Speedwell).—Fl. May 8th, Combe Down, L.W.R.

66. *Mentha aquatica* (Water Mint).—Fl. Aug. 6th, Ham Green, L.W.R.

67. *Thymus serpyllum* (Wild Thyme).—Fl. June 10th, Gully, L.W.R.

68. *Prunella vulgaris* (Self Heal).—Fl. June 4th, Temple Cloud, L.W.R.; June 6th, by 1st, Hamp Field, A.B.

69. *Nepeta glechoma* (Ground Ivy).—Fl. April 9th, Pill Road, L.W.R. ; March 19th, Durleigh, A.B.

70. *Lamium galeobdolon* (Archangel).—Fl. April 30th, Frome Glen, Mons. Pellissier.

71. *Stachys sylvatica* (Hedge Woundwort). — Fl. June 16th, by 3rd, Canal, A.B.

72. *Ajuga reptans.*—Fl. April 26th, under Sea Wall, L.W.R.; May 14th, by 3rd, near Cannington, A.B.

73. *Primula veris* (Cowslip). — Fl. April 16th, Combe Down, L.W.R. ; March 26th, River-side, A.B.

74. *Plantago lanceolata* (Ribwort Plantain). — Fl. May 12th, Clifton, L.W.R. ; April 11th, by 3rd, Hamp, A.B.

75. *Mercurialis perennis* (Dog's Mercury).—Fol. March 16th, Proctor's Fountain, L.W.R. ; Fl. April 1st (male), Durdham Down ; April 2nd (female), L.W.R.

76. *Ulmus montana* (Wych-Elm). — Bud b. April 15th, Downs, L.W.R. ; Fol. May 25th, Downs, L.W.R.

77. *Salix caprea* (Great Sallow).—Fl. April 3rd, Leigh Woods, L.W.R.

78. *Fagus sylvatica* (Beech). — Bud b. May 7th, King's Parade, L.W.R. ; Fol. May 16th, King's Parade, L.W.R. ; Fl. May 24th, Leigh Woods, L.W.R. ; R. fr. Sept. 6th, Leigh Woods, L.W.R.

79. *Corylus avellana* (Hazel). — Fol. April 30th, Osborne Road, L.W.R. ; Fl. Feb. 10th, Proctor's Fountain, L.W.R.

80. *Orchis maculata* (Spotted Orchis). — Fl. May 31st, Gully, L.W.R.

81. *Iris pseud-acorus* (Yellow Iris). — Fl. June 5th, Pensford, L.W.R.; May 21st, Petherton Levels, A.B.; R. fr. Nov. 5th, King's Parade (shady site), L.W.R.

82. *Narcissus pseudo-narcissus* (Daffodil).—Fl. April 6th, Failand, L.W.R.; Feb. 24th, Huntstile, A.B.

84. *Scilla nutans* (Bluebell).—Fl. April 6th, Markham Bottom, L.W.R.; April 26th, by 1st, Moorland, A.B.

INSECTS.

Recorders: Charles Bartlett, Redland (C.B.); G. C. Griffiths, F.E.S., Clifton (G.C.G).

Abbreviations.—App., first appearance; G.c., getting common.

1. *Cicindela campestris* (Tiger-beetle).—App. April 23rd, Gully; several seen, C.B.

2. *Melolontha vulgaris* (Cockchafer).—App. May 24th, Dundry, G.C.G.; May 25th, Westbury, swarmed at gas lamps, C.B.

3. *Rhizotrogus solstitialis* (Fern or Small Chafer).—App. July 1st, Combe Dingle; swarmed round oak trees, C.B.

6. *Lampyris noctiluca* (Glow-worm).—Feb. 13th, Leigh Down, under a stone, ♀, C.B.; April 19th, Brockley, three ♀, C.B.

7. *Meloe prescarabæus* (Oil Beetle).—App. April 3rd, Combe Dingle, C.B.

10. *Timarcha lævigata* (Bloody-nose Beetle, or Blood Spitter).—App. March 27th, Combe Dingle, taken by Mr. W. B. Waterfall, C.B.; G.c. April 19th, Brockley, very common, C.B.

11. *Chrysomela polita*.—App. March 12th, Westbury, C.B.

12. *Cassida Viridis* (Helmet Beetle).—App. Aug. 8th, Sneyd Park, five from thistles, C.B.

13. *Coccinella bipunctata* (Lady Bird).—App. April 8th, Redland, C.B.

15. *Vespa vulgaris* (Wasp).—App. April 9th, Duchess Pond, commoner than usual at ivy, C.B.

17. *Pieris rapæ* (Small Garden White or Cabbage Butterfly).—App. March 19th, Redland Road; a pupa on a wall at Clifton hatched between the 12th and 19th of March, C.B.; April 1st, Clifton, one specimen, one seen also on April 10th; I saw second brood for the first time on June 21st, G.C.G.

19. *Pieris Brassicæ* (Large Garden White or Cabbage Butterfly).—App. April 24th, Redland Green, ♀, C.B.; May 25th, Clifton, G.C.G.; G.c. June 6th, Dundry; very abundant during early part of June, G.C.G.

20. *Anthocaris cardamines* (Orange-tip Butterfly).—App. April 10th, King's Weston Park, ♂, C.B.; May 15th, Clifton, G.C.G.

21. *Epinephile janira* (Meadow-brown Butterfly).—App. June 22nd, Leigh, C.B.; June 22nd, G.C.G.

24. *Tephrosia crepuscularia* (Small Engrailed Moth).—App. April 23rd, Leigh Woods, at intervals between this date and June 23rd, fair average numbers, G.C.G.

25. *Tæniocampa gothica* (Hebrew-character Moth).—App. March 20th, Redland Green, C.B.; abundant in Leigh Woods from April 4th to 11th, G.C.G.

26. *Tæniocampa instabilis* (Clouded Drab Moth).—App. April 5th, Leigh, G.C.G.; G.c. abundant in Leigh Woods from April 4th to 11th, G.C.G.; April 5th, very abundant, Leigh, C.B.

27. *Tæniocampa stabilis* (Common Quaker Moth).—App. April 2nd, Leigh, C.B.; G.c. abundant in Leigh Woods from April 4th to 11th, G.C.G.; April 6th, Leigh, very abundant, C.B.

28. *Tæniocampa cruda* (Small Quaker Moth).—App. April 5th, Leigh, C.B.; G.c. April 6th, hundreds seen on sallow bloom, C.B.; abundant from April 4th to 11th, G.C.G.

29. *Tæniocampa munda* (Twin-spot Moth).—App. April 5th, Leigh, C.B.; G.c. April 5th, Leigh, C.B.

30. *Brephos parthenias* (Orange Underwing Moth).—App. March 19th, Leigh, C.B.; March 19th, Leigh Woods, seen for about a week after this date, G.C.G.; G.c. March 30th, Leigh, C.B.

31. *Diurnea fagella*.—App. April 2nd, Leigh, C.B.; G.c. April 5th, Leigh, C.B.; April 11th, this species was not so abundant as in some seasons, G.C.G.

MISCELLANEOUS.

1. *Frog Spawn*.—App. March 20th, Westbury, C.B.

The year has been a fair average one as regards the abundance of Lepidoptera, and has been remarkable for the large number of Colias Edusa (Clouded Yellow Butterfly) seen throughout England, but, as usual, more particularly along the south coast, in some localities of which it appeared in thousands. No such abundance of this insect has been noticed since 1877.

Locally, the year has produced our local rarity, *P. sicula*, a few specimens of which were taken in both larval and imago state by Mr. R. M. Prideaux, Mr. C. Bartlett, and myself.

Geo. C. Griffiths.

Notes on Meteorological Observations at Clifton College for the year 1892.

(230 Feet above Mean Sea Level.)

By D. RINTOUL, M.A.

In the following notes the outstanding features of each month's weather are first described, and the temperature and rainfall observations are summarized in a series of tables.

January.—The mean temperature for this month was 37·07 degrees, as compared with an average for the month of 39·41 degrees. This deficiency was most marked in the earlier part of the month, since the mean temperature was below the normal for the first three weeks, except on the 1st and 6th of the month, when it was just above the normal. There was frost on the ground on 18 days, and the mean air temperature was below freezing point on 8 days. The lowest temperature reached was 22·3 degrees on the 16th, and the highest 48·3 degrees on the 23rd and 29th. On the whole then, it may be said that this was an exceptionally cold January, the coldest period extending from the 7th till the 17th.

The barometer was below 30 inches from the 5th till the 23rd. There were two well-defined periods of low pressure about the 7th and the 16th, while the pressure was very fluctuating in the end of the month.

February.—The mean temperature for this month was

38·89 degrees, as compared with the average of the previous ten years of 40·20 degrees. This low mean was caused by a period of very cold weather, extending from the 12th to the 21st, the temperature for the rest of the month being nearly normal. The mean daily temperature was below freezing point from the 16th to the 19th, both included, and the thermometer never rose to freezing point on two of these days.

The lowest temperature in the screen was 17·3 degrees on the 17th, and the highest temperature 50 degrees on the 8th.

As regards pressure, the month may be divided into two periods, one of high pressure from the 8th to the 14th, and one of low pressure from the 14th to the 26th. On the 19th the extremely low reading of 29·043 inches was observed.

March.—This again was a very cold month, the mean temperature 37·59 degrees, being 4 12 degrees lower than the average of the preceding ten years. In fact, there were only five days in which the mean daily temperature was above the average, and on eight days it was below freezing point. There was frost on the ground on 23 days, the lowest temperature recorded being 22·4 degrees on the 13th.

In the first fortnight the mean temperature was about freezing point. There is nothing of special interest to be noted in the barometrical readings, except the very high barometer of the 30th, 30·610 inches.

April.—The mean temperature was 47·49 degrees, or about 10 degrees higher than the mean for March, and 1·35 degrees higher than the average of the last ten Aprils. There were, however, very great variations of temperature; the maximum thermometer reading over 70 degrees on the 3rd and 6th, and falling as low as 42 degrees on the 13th.

In two days, from the 11th to the 13th, the maximum readings fell from 66·3 degrees to 41·5 degrees, or a drop of nearly 25 degrees. The first 12 days were much hotter than usual, and the next 9 days almost as much colder.

Another remarkable feature of this month's temperature was the very great difference between the highest and lowest temperatures recorded on the same day. On the 10th the difference was 32 degrees!

May.—This month again was warmer than usual, the mean temperature being 54·29 degrees, or 2·4 degrees higher than usual. This excess was most noticeable towards the end of the month, the mean daily temperature of the last week being about 7 degrees higher than usual. The highest temperature recorded in the screen was 75·3 degrees on the last day of the month, and the lowest 35·2 degrees on the first.

June.—The mean temperature was 58·09 degrees, as compared with an average of 58·62 degrees. This month was therefore an average one as regarded temperature. There were some very hot days about the beginning of the month, the highest temperature recorded by the sheltered thermometer being 79·4 degrees on the 9th.

July.—The mean temperature for this month was 59·55 degrees, as against the mean for the preceding ten years of 60·52 degrees, thus showing a deficiency of nearly a degree. The highest temperature recorded in the shade was 79·5 degrees on the 3rd, while the highest mean temperature was 68·1 degrees on the same day. The lowest temperature in the screen was 47·5 degrees on the 21st. The *maximum* shade temperature fell below the average daily temperature on four days.

The barometer was very variable and generally low during the first half of the month, but on the last ten days it was high and fairly steady.

AUGUST.—This month was hotter than usual, the mean daily temperature being 61·05 degrees as compared with the normal value 59·34 degrees. This warmth was distributed evenly over the month, there being no very hot days, and only six days on which the mean daily temperature fell below the normal. The highest temperature registered in the screen was 75·1 degrees on the 22nd, and the lowest 45·3 degrees on the 11th.

SEPTEMBER.—The mean temperature of this month was 55·56 degrees, the normal mean temperature of the month being 56·76 degrees. The month was therefore slightly colder than usual. The beginning of the month was colder than usual, the rest of the month being of about the average temperature.

The highest temperature recorded was 66·8 degrees on the 19th, and the lowest 41·3 degrees on the 18th. From this also it will be seen that the variations of temperature were somewhat rapid.

OCTOBER.—The mean temperature for this month was 45·42 degrees, the average of the last ten years being 49·25 degrees. The month was therefore much colder than usual, being the coldest October of the last ten years. In fact, there were only two days—and these at the very end of the month—on which the mean daily temperature was above the normal. It is seldom that the mean daily temperature remains so steadily under its normal value as it did during this month.

The highest temperature recorded in the shade was 57·3 degrees, and the lowest in the screen 29·1 degrees. The lowest temperature on the ground was 27·3 degrees, and there was frost on the ground on seven nights.

There was one period of fairly high pressure from the 17th to the 20th inclusive, but the barometer was low

during the greater part of the month, especially so on the 28th and 29th.

NOVEMBER.—The mean temperature of the month was 43·83 degrees, the average of the last ten years being 44·13 degrees. The month was therefore slightly colder than usual. The highest temperature recorded in the screen was 57·3 degrees on the 14th, and the lowest 31·7 degrees on the 8th. There was frost on the ground on five nights.

DECEMBER.—The mean temperature of this month was 36·69 degrees as compared with a normal value of 39·51 degrees. The month was therefore much colder than usual. This defect was mainly due to the weather of the last week of the month, which was extremely cold.

Up to the 22nd the mean temperature was above 40 degrees, but from the 23rd till the end of the month the mean daily temperature was below freezing point. On seven out of the eight last days of the month, even the maximum temperature never reached as high as freezing point, while on the 27th the thermometer on the ground fell to 14·9 degrees. This is the lowest temperature recorded since 1887. There were 21 nights of frost.

1892 TEMPERATURES.

MONTH.	Maximum in Shade.		Minimum in Shade.		Mean in Shade.	Minimum on Ground.
	Highest recorded.	Mean.	Lowest recorded.	Mean.		
January .	48·3	41·07	22·4	33·07	37·07	22·3
February .	50·3	43·10	17·3	34·67	38·89	19·6
March . .	60·5	43·78	23·7	31·41	37·59	22·4
April . .	70·5	56·81	28·7	38·17	47·49	27·6
May. . .	75·3	61·90	35·2	46·67	54·29	32·0
June . .	79·4	64·97	42·0	51·22	58·09	39·4
July. . .	79·5	65·99	47·5	53·10	59·55	43·7
August .	75·1	67·22	45·3	54·87	61·05	42·2
September	66·8	60·78	41·3	50·34	55·56	38·6
October .	57·3	50·54	29·1	40·30	45·42	27·3
November	57·3	47·63	31·7	40·02	43·83	29·5
December.	50·3	40·67	18·4	32·72	36·69	14·9
Year 1892	79·5	53·71	17·3	42·21	47·96	14·9
Year 1891.	79·1	54·59	15·2	42·70	48·64	15·2
Year 1890.	76·0	55·16	19·1	43·40	49·28	17·2
Year 1889.	80·5	55·22	22·2	43·60	49·41	18·2
Year 1888.	79·1	54·19	22·3	42·74	48·45	18·0
Year 1887.	82·8	56·0	20·4	40·9	48·4	11·7
Year 1886.	83·5	54·90	21·7	43·17	49·03	15·3
Year 1885.	87·8	53·98	22·1	42·53	48·09	20·1
Year 1884.	87·5	57·44	22·6	44·07	50·66	23·7
Year 1883.	82·5	54·54	20·9	42·88	48·71	19·3
Year 1882.	78·5	55·46	21·9	43·62	49·54	20·6
Year 1881.	86·9	55·44	12·3	42·92	49·18	5·8

MONTH.	Number of Days on which the Minimum Ground Temperature was below 32°F.	Number of Days on which the Minimum Air Temperature was below 32°F.	Number of Days on which the Maximum Air Temperature was below 32°F.	Number of Days on which the Mean Air Temperature was below 32°F.
January . .	17	15	0	8
February. .	11	7	2	4
March . . .	23	17	2	7
April . . .	8	5	0	0
May . . .	0	0	0	0
June . .	0	0	0	0
July . . .	0	0	0	0
August . .	0	0	0	0
September .	0	0	0	0
October . .	7	2	0	0
November .	4	1	0	0
December .	21	15	7	8
Year 1892 .	91	62	11	27
Year 1891 .	83	57	8	20
Year 1890 .	79	57	16	31
Year 1889 .	88	45	5	12
Year 1888 .	93	60	2	16
Year 1887 .	148	63	2	11
Year 1886 .	102	64	1	22
Year 1885 .	68	40	1	6
Year 1884 .	51	19	0	1
Year 1883 .	79	40	0	6
Year 1882 .	63	26	2	7

MEAN SHADE TEMPERATURES OF THE MONTHS.

MONTH.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	Mean of last Twelve Years.
January . .	40·7	42·3	44·2	38·7	35·5	41·5	38·5	37·2	43·8	35·8	37·1	38·92
February .	42·6	43·3	42·3	44·0	35·8	41·0	36·1	39·0	38·7	42·0	38·9	40·24
March . .	45·7	37·0	44·9	41·7	40·1	39·9	38·6	41·5	44·7	39·6	37·6	41·19
April . . .	48·8	47·5	45·1	46·7	46·4	42·2	44·1	46·1	47·3	44·9	47·5	46·16
May . . .	53·7	49·9	53·3	47·0	52·2	45·5	52·5	55·8	54·9	50·0	54·3	51·96
June . . .	56·0	57·2	59·8	58·4	58·8	62·4	57·9	61·3	57·5	60·1	58·1	58·70
July . . .	59·6	57·2	60·7	62·6	62·7	63·9	58·4	61·1	59·1	59·9	59·6	60·89
August . .	60·2	60·6	64·5	57·5	59·1	60·4	59·3	59·2	59·4	58·3	61·1	59·86
September .	53·9	55·3	59·4	54·5	58·2	53·7	57·3	56·9	59·7	58·7	55·6	56·65
October . .	50·2	49·6	48·9	45·6	52·9	46·1	48·8	48·8	51·3	50·3	45·4	48·69
November .	43·7	42·8	41·6	43·3	47·1	41·2	47·2	46·7	44·9	42·8	43·8	44·45
December .	39·8	41·4	43·1	38·8	38·6	39·9	42·7	39·4	30·1	41·3	36·7	39·39
The Year .	49·5	48·7	50·7	48·1	49·0	48·4	48·45	49·41	49·28	48·64	47·97	48·93

RAINFALL.—MONTHLY SUMMARY.

	Inches.	Dr. Burden's Average, 38 Years.	Clifton College Average, 10 Years.	Departure from latter Average.	Number of Rainy Days.
January .	1·432	3·212	2·824	− 1·392	13
February.	2·040	2·213	1·720	+ 0·320	17
March . .	0·680	2·252	2·226	− 1·546	6
April . .	1·027	2·117	2·082	− 1·055	8
May . .	1·183	2·399	2·291	− 1·008	13
June . .	2·253	2·551	2·356	− 0·103	10
July . .	2 854	3·051	3·676	− 0·822	10
August .	3·926	3·410	2·990	+ 0·936	14
September	3·599	3·238	2·491	+ 1·108	18
October .	2·908	3·561	3·720	− 0·812	20
November	2·419	3·050	3·393	− 0·974	13
December	1·455	2·834	3·229	− 1·774	18
	25·776	33·888	32·9	− 7·222	160

From the above table it will be seen that the year was much drier than usual, the deficiency amounting to over seven inches. Out of the twelve months, only February, August, and September showed an excess. The greatest fall in 24 hours during the year occurred on the 17th of July, when 1·300 inches of rain fell. The other days on which more than an inch of rain fell were: June 2nd, August 28th, September 30th.

There were three periods of a fortnight or over without rain, viz.:—March 29th to April 12th, July 21st to August 5th, and December 18th to end of year. It is to be noted that the rainfall is measured daily, at 9 a.m.; and the rainfall therefore here indicated is to be taken as that falling during the 24 hours preceding 9 a.m. on the day mentioned. It is also to be noted that by "rainy days" is meant those in which the rainfall is ·01 of an inch or more.

On the Fish-Remains of the Lower Carboniferous Rocks of the Bristol District.

By A. J. HEATH, B.A., F.C.S., and C. LLOYD MORGAN, F.G.S., Assoc.R.S.M.

THE fish-remains of this district consist of teeth and spines, the latter being known as *Ichthyodorulites*. They belong to a group of the class of fishes termed the *Chondropterygii*, because of the cartilaginous or gristly character of the skeleton of the fins, or *Elasmobranchii*, from the plate-like form of the gills; and to a sub-group termed *Plagiostomi*, from the wide slit-like nature of the mouth.

Existing examples of the Plagiostome fishes are the sharks and rays; and since it is through them that we have some idea of what the fishes of our carboniferous limestone were like, it may be well briefly to describe some of their characteristic features. The body is either cylindrical and tapering at the ends, as in the sharks, or flattened from above downwards (in technical phrase "depressed"), as in the rays, of which the common skate is a familiar example. The slit-like mouth is on the lower surface of the head, and is

armed with a great number of teeth. In some cases the teeth are produced into sharp and pointed blades, which serve for holding slippery prey; in other cases they are blunt, rounded or flattened, and serve for crushing hard material, such as shells or coral. Each jaw, upper and lower, contains several rows of teeth, which are frequently arranged, not longitudinally, but in rows that run transversely and somewhat obliquely. The teeth are throughout life continually shed and as continually replaced. The new teeth are developed in a fold running along the inside of the jaw, and the whole pavement of the jaw with its numerous rows moves forward over the jaw to the outer edge, where they are torn away or shed. To allow of this process the teeth are not set in sockets, but merely imbedded in the membrane that covers the jaw. The fact that in different parts of the jaw of the same fish, as in the Port Jackson shark, teeth of both kinds, pointed and crushing, are developed, and that in the same jaw the numerous teeth are of different sizes and shapes, is one that must be borne in mind in dealing with the separate teeth that are found in a fossil condition. The tail of the shark-like plagiostome fishes is not externally symmetrical, like that of the herring or salmon, but unsymmetrical (*heterocercal*), the upper lobe being produced. In the rays the tail is often greatly elongated. There are two pairs of lateral fins, of which the anterior pair are the larger, and are in the rays extended so as to form the flattened wing-like sides of the fish. There are several gill-slits on each side of the head, and these are not covered over with a gill-flap, or opuculum, such as is seen in our commoner fishes which belong to quite a different group—that of the Teleosteans. The scales are peculiar. They consist as a rule of smaller or larger separate plates which bear sharp tooth-like points composed of tooth-like substance. In the

dog-fish these plates are small and close-set, and form what is called "shagreen"; in some of the rays, like the thornback skate, they form large dermal tubercles. Lastly, the skeleton, including the skull and vertebral column, is generally gristly or cartilaginous, and therefore readily decomposes. Hence the parts which are susceptible of fossilization and preservation in such a rock as our carboniferous limestone are the teeth and scales, and the spines, which sometimes support the dorsal fins, as in the Port Jackson shark, or project from the hinder part of the head.

We may therefore picture to ourselves the fishes of the mountain or carboniferous limestone period as shark-like or ray-like forms with broad mouths, armed with sharp or crushing (palatal) teeth, with shagreen-like skins, and sometimes armed with strong spines (ichthyodorulites). They seem to have chiefly abounded in the earlier times of the lower limestone shales (lower transition beds between the old red sandstone and the carboniferous limestone) and in the lower limestone. In the upper part of the limestone and in the upper limestone shales (or upper transition beds between the carboniferous limestone and the millstone grit), they are far less numerous, and are very rare in the millstone grit itself. The fish palates have chiefly been found in a special bed (the palate bed) in the lower limestone shales just above the so-called Bryozoa bed; and in special bands in the black-rock limestone. We know that the lower carboniferous limestone sea was crowded with encrinites, and may surmise that the ancient plagiostomes browsed on these old sea-lilies, the indigestible parts of which passed through them and contributed to the calcareous matter of the limestone. Perhaps the fishes of the upper limestone period browsed in a similar way on the abundant lithostrotion corals.

Passing now to the remains of fishes found in these lower carboniferous rocks in the Bristol district, we may first take notice of the teeth. There are certain primitive elasmobranchs in which the vertebral column is not clearly divided up into distinct vertebræ, and to which the name *Ichthyotomi* is applied by some authors. To this group belong the genus *Pleuracanthus*, the remains of which have been found in some abundance in the North of England and Scotland, but are not found in this district. A second genus, belonging to a different family, the *Cladodontidæ*, has afforded teeth which consist of a central sharp, flattened cone, flanked on either side by smaller points. This genus, *Cladodus*, seems to have had a broad and depressed head, in the jaws of which the teeth were arranged in several rows. A *Cladodus* tooth was found some years ago in the millstone grit at Long Ashton by Mr. Dallas, who was then curator of the Bristol Museum. Other specimens have been found in the carboniferous limestone. These primitive forms are by some palæontologists regarded as early forms of selachians, to which the name *Proselachii* is by them applied.

To this group, perhaps, belongs the family of the *Cochliodontidæ*, of the teeth of which Sir Richard Owen remarked in 1867 that "it would seem as if the several teeth of each oblique row in *Cestracion* [the Port Jackson shark] had been welded into a single mass." The Cochliodont teeth were formed in a continuous curved plate, sometimes with a smooth crown, sometimes with one marked with grooves and ridges, which seem to indicate the separate factors of the compound tooth. Additions seem to have taken place at the inner borders, while the outer borders curved round continuously instead of becoming detached. The genera belonging to this family which are represented in our limestone are *Streblodus*, *Psephodus*, *Chomatodus*, *Tomodus*, *Deltodus*, *Deltoptychius*,

Xystrodus, and *Sandalodus*, while some of the teeth named *Helodus* are very probably derived from the anterior part of the jaws of fishes of this family. Among these the huge teeth of *Sandalodus* are noteworthy. A tooth of this genus in the cabinet of University College, Bristol, is triangular in shape, the sides of the triangle being about twice as long as the base. The crown is undulating, and towards the broader end layers of growth are readily discernible. The whole surface is pitted with small depressions. The length of the tooth is $3\frac{1}{2}$ inches. It was probably the upper dental plate of the fish. Commoner, if less striking, are the teeth of *Psephodus*, the margin of the crown of each tooth being more or less crenulated. On the other hand, the teeth of *Tomodus*, also a not-uncommon form, are characterized by a straight margin with an abrupt edge. The crown is smooth, punctate, and gently arched with an outer apex strongly inrolled. In *Deltodus* there are numerous rounded transverse ridges and furrows running parallel to the inner border; while in *Deltoptychius* there is one large broadening ridge, extending from the outer apex to the inner margin, an abrupt up-ridging of the borders of the tooth giving it a characteristic twisted appearance. The type specimen in the Bristol Museum, described by Agassiz as *Cochliodus contortus* (*Psammodus contortus* on the plate), is now referred to as *Deltoptychius gibberulus*.

The family *Cestraciontidæ* is represented to-day by the before-mentioned Port Jackson shark of the Australian seas. To this family belongs the genus *Orodus*, whose large and handsome teeth are often found in the quarries in the black-rock limestone. The teeth are elongated from side to side, the crown gently rising towards an eminence in the middle. Its surface is characteristically marked with wrinkles and furrows radiating towards each long margin. By the abrasion

of these wrinkles the crown was gradually worn smooth, and separate generic and specific names (*e.g.*, *Helodus subteres*) have been given to such worn teeth. The genus *Orodus* probably differs but slightly from the Mesozoic genus *Hybodus*, the teeth of which are common in the Rhætic of Aust Cliff. Three species—*Orodus ramosus*, *O. sculptus*, and *O. cinctus*—have been found in the Bristol limestone.

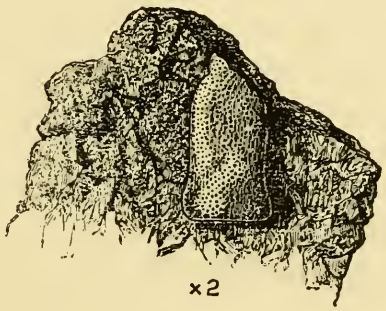
In passing to the family *Petalodontidæ*, we pass to fishes which were most probably depressed like the existing rays, and had large wing-like pectoral fins produced forwards in the direction of the head. The teeth covered the jaws in the form of a pavement of overlapping petal-shaped or ribbon-shaped flattened denticles, the free points or edges of which were directed backwards. The edges were smooth or slightly crenulated, and the root or base of insertion was relatively large. Teeth of *Petalodus linearis*, narrow and rectangular, with fine crenulations over the free long edge, have been found in the palate bed of the lower limestone shales, and less abundantly in the black-rock limestone. *P. recurvus* is a rarer form. A specimen in the British Museum (Nat. Hist.), labelled *P. Hastingsiæ* (Owen), is referred by Mr. Smith Woodward to *P. acuminatus* (Ag.).

Another extinct family, only known by parts of its dentition, is that of the *Psammodontidæ*. The teeth are quadrangular and flattened with a root or base of insertion nearly as large as the crown or hardened crushing substance. They appear to have been arranged in one or more longitudinal rows, probably alternating somewhat in adjacent rows. Teeth belonging to the typical *Psammodus* are generally oblong, though sometimes nearly square. The base is thicker than the crown, and easily separable from it. Transverse wrinkles in some species mark the crown. In this fish the slit-like mouth was probably but slightly arched

forwards, and this seems to indicate that the body may have been depressed like that of the rays.

Referable to this genus is a small tooth in the cabinet of University College, Bristol, which would seem to be of special interest. It forms part of a collection which was made by the late Mr. Malthus, and was presented to the College by his son, Col. Malthus. It is slightly broken at one end, 10 mm. in length, and 5 in maximum breadth, and about $2\frac{1}{2}$ in maximum height. It rises with a gentle hollow curve to a rounded apex, situate near one end of the tooth, which is then cut off abruptly by a vertical face which, though slightly worn, is natural, and not the result of fracture. The surface of the tooth is marked with numerous and fairly close set pits. Mr. A. Smith Woodward, to whom one of us submitted the tooth, says: "In shape this is identical with *Psammodus angustus* (Romanowsky), from the carboniferous limestone of Moscow; but it is of smaller size. Adopt the specific name provisionally." If the provisional reference to this species be correct, this form is new to our limestone, and, we believe, new to England. The tooth was placed in association with a number of other palates which were not named. Nor was the locality from which they were derived recorded. It is therefore *possible* that it is foreign. But if so, it is the only foreign tooth in the collection. Many of the other specimens found with it in the collection are undoubtedly from the palate bed of the lower limestone shales. And the rock in which the tooth is embedded precisely resembles in character that which constitutes this remarkable and easily recognisable local deposit. We have, therefore, little doubt that the tooth is local and from the palate bed of the lower limestone shales. But, in the absence of direct record, this must remain only a very strong probability. One could not have a more telling illustration of the extreme im-

portance of always recording at once the locality from which any fossil is obtained. The name is comparatively immaterial; that can be supplied later. But a record of the locality is of essential importance. In view of the interest of this specimen, whether, as we confidently believe, it is local or not, we have inserted a figure, drawn by Mr. Edwin Wilson, twice the natural size of the tooth.



This completes the list of Elasmobranch families which are represented by their teeth in the lower carboniferous rocks in the Bristol district. We shall give a table of the genera and species after we have briefly described (1) the minute structure of the teeth and (2) the Ichthyodorulites.

To examine the minute structure of some of the teeth we have made a series of sections and slices, polishing the former for examination with a hand lens, and mounting the latter for microscopic examination. A polished section of an Orodus tooth exhibits to the naked eye a base somewhat irregularly eroded, surmounted by the curved crown. The whole of the basal part is stained a deep red with oxide of iron; but the upper part is a dull white, streaked with red where the vascular canals pass through it towards the surface. Examined with a lens, the basal part is seen to have a spongy or net-like structure, the strands of which represent the calcified cartilage, while the hollows were probably

occupied by soft tissue which decomposed and left spaces which have been filled in with a greyish brown limestone paste. From this spongy basal substance there springs, where the base passes into the crown of the tooth, a series of vascular canals, which radiate upwards towards the outer and upper surface of the tooth, and are filled with a red ferruginous material. These vascular canals, the presence of which, together with the dentinal tubules that branch out from them, causes the tissue to be called vaso-dentine, occasionally branch and pass to the surface, forming, in this specimen of a well-worn tooth, the punctate pits of the surface. We have ground down the apex of the tooth, so as to show a section at right angles to the direction of the vascular canals, which appear as red spots on a pinkish white ground. The edges of this section shade off into the outer surface of the worn tooth, and by comparing the two we are able to state that in this specimen the pitting of the surface, as it now exists, is the expression of the vascular canals. We draw attention to this point because whereas Agassiz stated that the punctate crown of *Psammodus* and similar teeth was related to the internal structure of the tooth, Owen affirmed that the impressions of the surface are entirely unconnected with the vascular canals or internal structure. Sir Richard Owen regarded them as so formed in the tooth germ, and as only natural adaptations to the habits and food of the species. This difference of opinion between two such careful observers may perhaps be explained on the supposition that Agassiz examined worn teeth while Owen described an unworn specimen. We have not been able to confirm Owen's observation; but since the specimens we have examined are all more or less worn, this does not show that the observation was incorrect.

Examined under the microscope, a thin slice of a *Psammo-*

dus tooth, cut in longitudinal section, exhibits the almost parallel vascular canals running perpendicularly to the surface. The interspaces are about six times the diameter of the tubes. From them there proceed the extremely fine branching dentinal tubules before mentioned, which traverse the interspaces of calcified tooth-substance in fine, wavy, dendritic lines. In this tooth the passage from crown to root appears more abrupt than it is in *Orodus*, *Psephodus*, or *Helodus*. In a section of the tooth of *Psephodus* the vascular canals, as they approach and pass into the base of the tooth, become wavy and coiled, pursuing a sinuous course. In one slice of *Orodus* the minute structure is well shown, and the relation of the red staining material (presumably some iron compound) to the canals is well shown. The lumen of the tube is bordered by a lighter, clearer band, in which and through which the dentinal tubules branch out. Into this band, and sometimes beyond it, the red material, which is perfectly translucent under the microscope, has passed irregularly by infiltration. The edge of the stained part therefore presents an irregular mammillated wavy or sinuous curve. In none of our transverse sections do we find definite indications of concentric lamellæ like those of the Haversian canals in bone.

We pass now to a brief notice of the ichthyodorulites, or fish-spines.

Certain laterally compressed, robust, and often large spines have been found in the Bristol rocks. They are generally marked by ridges extending from the pointed end to within a short distance of the more rounded extremity. Small denticles, or wrinkles, appear between these ridges. The spine seems to have been sharp in front, while the hinder part was concave or flat, with small tooth-like excrescences along each margin. They go by the generic name of

Ctenacanthus; but, as Mr. Smith Woodward points out, the fact that the largest spines of *Ctenacanthus* yet found in Britain occur in our own neighbourhood, and in close connection with the largest discovered teeth of *Orodus*, seems to show that the spines of *Ctenacanthus* and the teeth of *Orodus* may have belonged to the same genus of fishes. The spines are most numerous, too, at Armagh, where the teeth of *Orodus* are found in the greatest abundance. The spines were probably dorsal in position, and would seem to have been deeply imbedded in the back, and therefore immovable. It is quite possible that somewhat similar spines, all classed together as *Ctenacanthus*, may have been possessed by several allied genera. The specimens of those species of Ctenacanthus (*C. major*, *tenuistriatus*, *C. brevis*, and *C. sulcatus*) are in the Bristol Museum.

Another hook-shaped or strongly arched ichthyodorulite with a broad and shallow base of insertion is described under the generic name of *Physonemus*. Small denticles are found on the concave edge, and lumpy longitudinal ridges ornament the remainder of the free portion. Two species, *Physonemus arcuatus* and *P.* (*Onchus*) *hamatus*, have been found in the limestone of this district. The type specimen of *hamatus* is in the Bristol Museum.

A broad triangular and somewhat arched ichthyodorulite is known as *Oracanthus*. It often attains a large size, a specimen in the British Museum (Nat. Hist.) of *Oracanthus pustulosus* (*Phoderacanthus grandis*) from Bristol being three feet in length. It is compressed laterally, and the base of insertion is short or altogether absent. The spines are unsymmetrical, and were probably arranged in pairs. Not improbably, as suggested by Dr. Traquair, they formed backwardly directed weapons behind the head. It was suggested by Agassiz that the teeth of *Orodus* and the

spines of *Oracanthus* were different parts of the same fish. Mr. R. Etheridge, junr., has given the arguments in favour of their being associated with *Psammodus*. *Polyrhizodus* (one of the *Petalodontidæ*) has been suggested in like connection; but teeth of this genus are not found in the Bristol limestone, while *Oracanthus* spines abound. The type specimens of two species, *O. Milleri* and *O. pustulosus*, are in the Bristol Museum.

It now only remains to add a list of the species of teeth and spines which have been found in the Bristol limestone. A capital T has been placed after the names of those species, type specimens of which are preserved in the Bristol Museum. It will be seen at a glance how rich that collection is in type specimens of these interesting fish-remains.

TEETH.

Cladodontidæ.

Cladodus marginatus (conicus) (Ag) (mirabilis McCoy), T.

Cochliodontidæ.

Streblodus Egertoni (Ag. MS.).
Psephodus lævissimus (Ag.), T.
„ magnus (McCoy).
Chomatodus cinctus (Ag.), T.
Tomodus convexus (Ag. MS.), T.
Deltodus gibbus (A. Smith Woodward).
Deltoptychius gibberulus (Ag. MS.).
Xystrodus Egertoni (J. W. Davis).
Sandalodus Morrisi (J. W. Davis), T.
Helodus turgidus (Ag.), T.

Cestraciontidæ.

Orodus cinctus (Ag.), T.
„ ramosus (Ag.), T.
„ sculptus (J. W. Davis), T.

Petalodontidæ.

Petalodus linearis (Ag.), T.
„ recurvus (J. W. Davis).
„ acuminatus (Ag.), (Hastingsiæ [Owen]).

Psammodontidæ.

Psammodus rugosus (Ag.), T.
„ var. porosus.
„ angustus (Romanowsky).

SPINES.

Ctenacanthus brevis (Ag.), T.
„ major (tenuistriatus), (Ag.), T.
„ sulcatus (Ag.), T.
Oracanthus Milleri (Ag.), T.
„ pustulosus (Ag.), T. (=Phoderacanthus grandis, J. W. Davis).
Physonemus arcuatus (McCoy).
„ hamatus (Ag.), T.

In conclusion we desire to acknowledge our special indebtedness to Mr. A. Smith Woodward's *Catalogue of Fossil Fishes in the British Museum*, Parts i. and ii., to which we would refer those who desire references to the original papers in which the several genera and species were first described.

Some Ancient British Remains on Clifton Down.

By ARTHUR B. PROWSE, M.D. Lond., F.R.C.S. Eng.

Read April 6th, 1893.

THE neighbourhood of Clifton is rich in pre-historic archæology, and many writers have dealt with it. There is, however, further evidence of ancient British industry at our very doors, which up to the present seems to have escaped special notice in every treatise to which I have referred.

Clifton Down, strictly speaking, is that portion of the breezy upland to the west and north-west of Clifton which lies within the civil parish of Clifton. This definition is not superfluous; for numbers of people, including even the officials of the Ordnance Survey, apparently understand by the term merely the Observatory Hill, together with the lower ground which extends from it eastwards to Christ Church, and northwards to the Fountain and Bridge Valley Road. This limited area is certainly not more than one-fourth of Clifton Down proper. Its true outward boundary runs from the foot of Walcombe Slade,—commonly known as the "Gully," or "Stoney Valley,"—up that depression to its head, and across the open down in a north-east direction to near the Reservoir. Thence south-east, in front of the Reservoir to the top of Blackboy Hill. North-west and north of this is Durdham Down, 212 acres in extent; Clifton Down being 230.

Geologically, most of this area is mountain limestone, rising to nearly 340 ft. by the Observatory, and about 320 ft. in front of Upper Belgrave Road. In the intervening depression, near the Fountain and Bridge Valley Road, there is dolomitic conglomerate; and between this and the Observatory Hill is more mountain limestone, and a wedge-edged area of millstone grit.

Before describing the special antiquities which suggested this paper, it will be well to mention briefly the various kinds of stone remains, which may reasonably be attributed to our ancestors in pre-Roman times. Seeing that we are ignorant of the exact purposes for which several of these antiquities were intended, the classification given is one based upon form, or shape, mainly :—

I. Chambers :—(1) Kistvaens; (2) Cromlechs; (3) Beehive Huts.

II. Circles :—(4) Hut-circles and Pit-dwellings; (5) Tumulus-rings; (6) "Sacred" circles.

III. Irregular Enclosures :—(7) Village Enclosures and Pounds; (8) Hut-clusters; (9) Forts and entrenched Camps.

IV. Linear Groups :—(10) Tracklines and Boundary-banks; (11) Trackways or Roads; (12) Stone Avenues or Parallelithons.

V. Mounds and Pillars :—(13) Barrows and Cairns; (14) Mining-heaps; (15) Menhirs or Monoliths.

VI. Weapons and Tools :—*c.g.* Celts, Arrowheads, Flint Scrapers, etc.

There are four other objects which have been classed as the work of man in pre-historic times; viz., Rock-basins, Logan stones, Tolmens, and Rock-idols (so-called). The three last of these are undoubtedly of *natural* formation, though they *may* have been utilised as objects of worship, or for purposes of divination in some cases. As to Rock-basins,

which are simply shallow excavations on the summits of rocks and boulders, generally at or near the tops of hills, I think there is little doubt that in most, if not all, cases, they originated by weathering of the rock-surface; but in many cases their shape is so regularly circular, and the margin so abrupt and well-defined, that it is difficult to imagine that they have not been subsequently modified by human art.

(1) KISTVAENS, when perfect, are composed of four slabs of stone set on edge, and more or less imbedded in the ground. The space enclosed is oblong and roughly rectangular, and was formerly covered in by another large slab when an interment took place of either cremated remains or an unburnt body. In some cases earthenware jars, and weapons of flint or metal, were deposited. The long diameter of the space, which is usually approximately north and south, rarely exceeds $4\frac{1}{2}$ or 5 feet; the width is not often more than $2\frac{1}{2}$ feet. In one recorded case the dimensions are only 2 ft. 9 in. by 1 ft. 6 in. Even in the largest of these cavities no adult body could be placed unless the knees were first bent up towards the chin.

Probably in all cases the "Kistvaen" was originally covered in with a mound of earth or stones, or both, forming a "barrow" or "cairn"; but in the course of ages the earth of the mound has often been entirely removed by weathering, and the stones by wall-builders or road-menders. The large slabs of the Kistvaen itself have too often been broken, or removed and put to other uses.

(2) CROMLECHS, which are often called Dolmens, consist of three large upright stones firmly fixed in the ground, supporting on their tops a huge slab several feet above the ground. Occasionally the supporters are more than three in number. In the only perfect specimen now existing in

Devonshire, the slab, which is raised aloft, is 15 ft. long, 10 ft. wide, and 2 ft. thick. The large stones at Druid Stoke are believed to be the remains of a cromlech; as are also those which form the group called the "Cove" at Stanton Drew.

(3) Beehive Huts.—These are dome-shaped dwellings, built of layers of loose stones, which gradually converge towards the centre. They are generally small in size, often not more than 5 or 6 feet in diameter, and 4 or 5 feet high. The low entrance is frequently bounded on either side by small stone posts or slabs, and generally faces south or south-east. The more perfect the building, the more likely it is to be comparatively recent; for even in modern times similar rude structures have been put up and inhabited. Some are, however, very ancient.

The more usual form of artificial dwelling in early times consisted of a low circular wall of uncemented stones surmounted by a series of arching boughs over which were spread the skins of animals, forming a protection from the weather. Such structures are now represented by rings of stones only, forming what are called—

(4) Hut-circles.—In this neighbourhood the centre of the space was often excavated to the depth of a few feet. Such pits when disused tend, of course, to become gradually filled up; and so, now, often all that is to be seen is a shallow circular depression marking what was once a perfect Pit-dwelling. The diameter of hut-circles varies from 8 or 10 feet to 30 feet, and, rarely, even more. Another kind of stone-circle is the—

(5) Tumulus-ring.—This, at one time, formed the outer boundary of a "barrow" or "earthen tumulus." The stones are usually flattish, and are fixed upright in the ground edge to edge. There may, or may not, have been a kistvaen origi-

nally in the centre of the barrow; for in *some* cases the ashes or cremated remains were simply deposited in a little hollow scooped in the ground, and then earth or stones piled up to form a tumulus. These circles vary from 20 feet in diameter to double, treble, or even a greater size.

(6) "SACRED" CIRCLES are quite distinct from the last mentioned. The number of stones composing them is fewer, and they are as a rule much larger—often several feet high,—and there is an interval of some yards between neighbouring stones. The diameter of these circles often exceeds 100 feet.

(7) VILLAGE ENCLOSURES and POUNDS are irregular in shape,—often oval, ovoid, or pyriform,—and the boundary is composed of a bank of stones and turf, which is more or less massive according to the character and abundance of the materials near at hand for use. They are usually placed on hill-sides gently sloping to the S.E., S., or S.W., but occur also on slopes facing other points of the compass. The size is very variable. The best known, perhaps, of all on Dartmoor, called Grimspound, one with a very massive stone boundary, has an area of four acres; but the largest there, with which I am acquainted, is more than three times this area. Its length is 340 yards, and its breadth 290. Within the space are about forty hut-circles. The term "village enclosure" is in such cases very appropriate for descriptive purposes; but when these enclosures contain no hut-circles, "pound" is the better term to use. The boundary-banks were formerly, of course, higher and more wall-like than now; and were probably in many cases surmounted by brushwood and gorse, to form a further protection to the inhabitants and their herds from wild animals and other dangers. When there are no remains of huts within the enclosures, there are almost always one or two close by for

the use of the herdsmen in charge of the animals within the pound.

(8) HUT-CLUSTER is the name given to the remains of irregularly-grouped contiguous dwellings. This antiquity in the West of England is by no means common. One only is at present known on Dartmoor; but doubtless others will yet be discovered.

(9) FORTS and ENTRENCHED CAMPS abound in this district. Stokeleigh Camp and Burgh Walls are close to us on the other side of the river. The former of these is in good preservation, but the latter has been nearly destroyed by building and gardening operations within the last few years. The camp on Observatory Hill has been often described, so nothing more will here be said of it.

(10) TRACKLINE, and BOUNDARY-BANK, are terms not strictly interchangeable. The former means a line of stones of moderate size fixed in the ground, and distant from each other several feet. The latter term is applied to low banks of earth and stones which extend in curved, sinuous, or nearly straight directions, often for long distances. The two are here classed together, because they often merge into one another, and appear to have been intended for the same purposes. In some cases they seem to have been meant as guides in the neighbourhood of settlements during thick misty weather, and by night; but more often they enclose irregularly rectangular oblong spaces of ground around groups of hut-remains. In such cases they may simply be the result of clearing the ground of loose stones from the surface or just below it, for the sake of tillage, or for improving the pasture.

(11) TRACKWAYS or ROADS were of the greatest importance in ancient as in modern times; and their value seems to have been recognised at a very early date, certainly before

the Romans invaded Britain. The latter people, of course, made immense improvements, but in numberless cases adopted the line of ancient trackways, remaking them on a better and more durable plan. The Fosse Way was almost certainly one of these ancient British tracks. After passing Exeter in the south-westerly course, it went on by Chudleigh, and across the middle of Dartmoor. Here its remains are now known as the "Great Central Trackway"; and here also it was little, if at all, modified by the Romans. Its width is about 10 feet, and its vertical depth 2 to 2½ feet. Rough stones have been rudely built together so as to form a raised causeway; and the minor irregularities of the surface were filled in with granite gravel, which abounds all over the moor. Compared with a typical Roman road built in several layers of different material, its structure is very simple; but it must nevertheless have well served its purpose.

(12) Stone Avenues, or Parallelithons, are, on Dartmoor, double, sometimes treble, rows of moderate-sized stones projecting 2 to 3½ feet above ground, and 3 or 4 feet apart, extending in nearly straight lines for variable distances, from a few feet to several hundred yards. There are remains of stone avenues, composed of much larger stones, on Salisbury Plain, and at Stanton Drew and other places in Great Britain; while abroad, the best known examples of somewhat similar antiquities are the huge stone lines at Karnac in Brittany.

(13) Barrows and Cairns are often included under the general term "Tumuli." The first term is applicable to those mounds which consist chiefly of earth; while the second implies that the heap is composed entirely of stones. They are often of large size, 30 yards or more in diameter, but are usually smaller; sometimes so weathered and reduced

by the storms of ages as to be hardly noticeable, and only 4 or 5 yards across. As to the shape, the Dartmoor examples are all "round"; there are none of the "long" type. On Salisbury Plain both kinds are found. Generally they are placed in situations commanding a very wide expanse of country, at or near the summits of the hills and downs, or upon the verge of steep slopes, and thus often form very prominent landmarks.

(14) MINING-HEAPS at a distance often resemble tumuli; but they are more often situated in the hollows and depressions of the hill-sides than at or near the summits. There are, of course, always pits and excavations associated with these heaps. Many such mining remains are of mediæval and modern date; but some, at least, are very ancient; and we know that tin was, perhaps, the most important article of export from western Britain in pre-Roman times.

(15) MENHIRS, or MONOLITHS, are pillars or elongated slabs of stone fixed erect in the ground. The finest specimen now on Dartmoor stands 11 feet high above the surface; but formerly, before the accumulation of peaty soil around it, the height must have been $13\frac{1}{2}$ feet above the more solid ground in which its base is imbedded.

(16) STONE WEAPONS and TOOLS form another group of remains, which need now be only mentioned.

As to the original uses of these varied monuments of the past, there is no doubt whatever that kistvaens, barrows, cairns, and tumulus-rings are sepulchral remains; that beehive-huts, hut-circles, village enclosures, hut-clusters, and camps are remains of human habitations; that the associations of mining-heaps, of trackways, and of weapons and tools are obvious; that tracklines and boundary-banks were largely due to the attempts to clear the ground near

dwellings, and to make it thus more valuable as pasture for cattle, etc.; but as to the intentions with which cromlechs, "sacred" circles, stone avenues, and menhirs were erected, there has been, and still is, so much difference of opinion that it would take a long time merely to state briefly the various theories which have been brought forward; and time so occupied would on this occasion be misused.

What groups of the foregoing antiquities are there represented on Clifton Down? Those which have hitherto been described by antiquaries are: (*a*) CLIFTON CAMP above St. Vincent's Rocks, and (*b*) PIT-DWELLINGS within its area; to which are added (*c*) guards-pits for archers, and (*d*) platforms and defensive banks for slingers, on the sides of the sloping approaches to the camp up Bridge Valley and in Walcombe Slade.

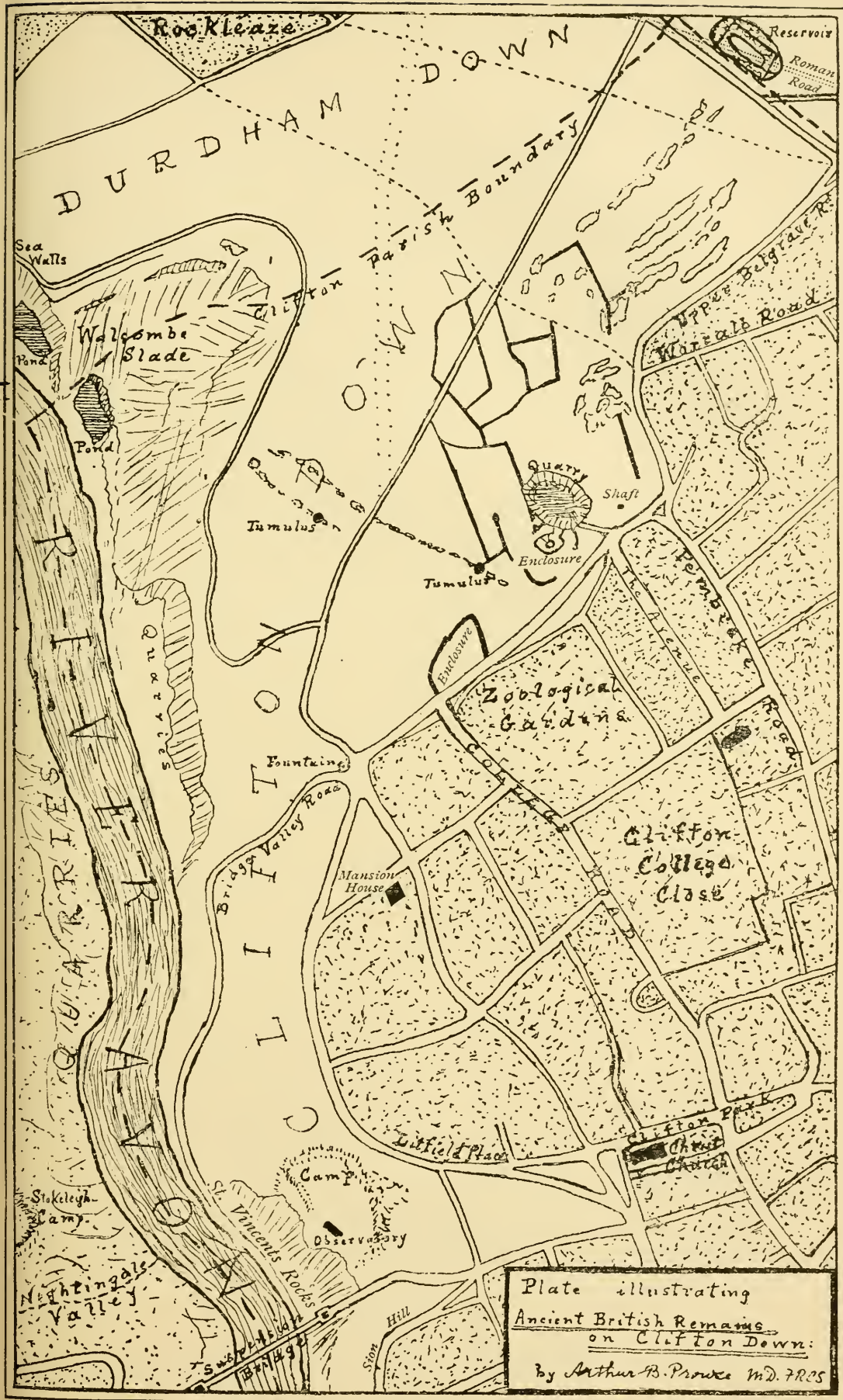
But in addition to these, which I do not intend to mention further, there are the following remains, which, with my brother's help, I have lately been mapping out, and which are shown on the plan which accompanies this:—TRACK-LINES or BOUNDARY-BANKS; portions of two ENCLOSURES or POUNDS; bases of two TUMULI; two lines of defensive PITS running across the top of the down—one from near the Pembroke Road quarry in a N.W. direction towards the slope this side of Walcombe Slade, and a second shorter one a few yards distant on the south-west of the former.

The wonder is there is so much still left to observe in these days; for the proximity of a large city means that every square yard of the downs, where not overgrown with thick bushes, is trampled yearly by thousands of feet; and this, of course, causes much wearing away of any object rising above the general surface. Then, again, the indiscriminating ravages of wall-builders, road-menders, and

agricultural "improvers," is in every part of the country a fruitful source of the destruction of numberless relics of the past.

On the map* are recorded a series of boundary-banks, extending from near the Zoological Gardens to beyond the footway leading from the end of Worrall Road across the down to Rockleaze. These banks are easily traced for the most part; but there are additional lines faintly marked here and there, about which there may be some doubt as to whether they are not merely *natural* markings of the surface; these, therefore, are not entered on the plan. The prevailing direction of the principal banks is from S.S.E. to N.N.W. In this they agree closely with the majority of those upon Dartmoor. The transverse banks, which connect the longitudinal ones, are shorter, and less regular in direction. One of the larger banks runs about 90 yards N. by W. from near the tunnel-shaft at the top of Pembroke Road, and is lost amongst some of the small superficial quarries opposite the end of Worrall Road. Observation shows that around these quarries, and the similar but larger ones which run in parallel lines from S.W. to N.E., near Upper Belgrave Road, there is little or no accumulation of earth and stones in the form of heaps. What was excavated has practically been all used for building or road-mending. This apparently trivial point is nevertheless of importance when considered in connection with the fact that in the series of shallow excavations, which run across the top of the down from S.E. to N.W. some distance to the west of the Pembroke Road quarry, most if not all of the excavated material seems to have been piled up around the hollows, and left there. These pits are also mostly small in size, and many are circular in outline. I believe them to be part of an ad-

* The scale of the map is 6 inches to 1 mile.


Rocklease
DURDHAM DOWN
Reservoir
Roman Road
Parish Boundary
Sea Walls
Clifton
Upper Belgrave Rd
Warrack Road
Walcombe Slade
Pond
Pond
Quarry
Shaft
Tumulus
Tumulus
Enclosure
Pembroke Road
The Avenue
Enclosure
Zoological Gardens
Fountains
Bridge Valley Road
Clifton College Close
Mansion House
Clifton Park
Clifton Church
Dittield Place
Camp
St Vincents Rocks
Observatory
Stakeleigh Camp
Nightingale Valley
Sion Hill
Plate illustrating
Ancient British Remains
on Clifton Down:
by Arthur B. Prowse MD. FRCS

vanced line of defence intended to protect the camp on Observatory Hill. Doubtless several of the smaller and rounder pits were used as actual dwellings.

Near the south-east end of *each* of these rows of pits is what I believe to be the remains of a TUMULUS; for the amount of soil and stones piled up is far in excess of what could have been removed from the depression in the middle of each. Much of it must have been carried there to increase the size of the mounds.

There is still left for description what I believe to be the remains of two POUNDS or VILLAGE ENCLOSURES. One is opposite the entrance to the Zoological Gardens; and a section of its enclosing bank of stones is plainly seen opposite the end of College Road. This bank extends N.W. for about 30 yards, and then bends round to the N.E. for about 120 yards further; then there is a sharp turn to the S.S.E., and the bank reaches the road again in 75 yards. The southern portion of this enclosure has been destroyed in making the road along the edge of the down. Within the area are no distinct traces of hut-circles or pit-dwellings; and I therefore conclude it was intended merely for the protection of cattle at night and on certain other occasions. It is on a slope facing S.S.E.; and to the north and west of it the ground rises considerably, thus giving shelter from the violence of westerly gales.

South of the large Pembroke Road quarry are remnants in three places of what was probably another VILLAGE ENCLOSURE or POUND. Within its area, and abutting upon the quarry, is an irregular space surrounded by a hedge; and within this again a circular space, about 13 yards across, bounded by a modern wall several feet high. Inquiries have led to the conclusion that both the hedge and the wall are about twenty years old. I suspect that

their outlines were suggested and determined by the presence of some ancient remains, such as a large hut-circle, with a second bank of stones surrounding it. This concentric arrangement is common on Dartmoor.

In conclusion, it need only be said that these antiquarian remains are probably only a portion of what a more prolonged and patient search will reveal; and I would urge those members of the Society who have much leisure time—and there must be several such—to employ some of it in making a more complete survey of the antiquities of the neighbourhood than has hitherto been carried out.

Local Engineering Works in Progress or Contemplated.

By FRANCIS FOX, M.Inst.C.E.

Read before the Engineering Section, Oct. 18th, 1892.

DOCK AND HARBOUR WORKS.—The most important local works are obviously those affecting the trade and interests of the port of Bristol. It has been for some time past evident that increased accommodation for vessels of great length and large tonnage is indispensable if some of the trade which would come to Bristol, if it possessed such accommodation, is not to be diverted to other ports. The enlargement of Avonmouth Dock is now in progress. When completed it will add 50 per cent. to the existing quay accommodation. It is proposed to use the extended dock for shipping coal and discharging timber. The cost is estimated at about £60,000, exclusive of coal-tips, lines, etc. A floating pontoon dock is also in course of construction at Avonmouth, which will enable vessels of about 4,500 tons displacement to be docked for examination or repairs. The flotation is obtained by six pontoons. A new traffic office is being built at Avonmouth at a cost of about £2,400. This extension is, however, quite inadequate, and the Docks Committee have therefore decided on recommending the construction of a new dock of about twenty-three acres area (which may readily be extended at a future time, if found necessary) on the north-east side of the present dock.

and connected with it by a junction-way 80 feet wide, so that vessels using the new lock could pass through to the existing dock. It is proposed that the new lock shall be 800 feet long and 80 feet wide, with sills 15 to 16 feet lower than those of Avonmouth Dock, so that large vessels will be able to lock in and out at half-tide. Quay accommodation for three of the largest Atlantic liners would be afforded, and turning room for a vessel nearly 800 feet long. In the event of the dockisation of the Avon, vessels could enter or leave by the two locks, and enter or leave the dockised river at the south-west angle of the dock. The scheme also includes a graving-dock for vessels of the largest class, with space for a second graving-dock at any future time. The estimated cost of the new dock, lock, junction-way, graving-dock, sheds, and railway connections is £850,000. In addition to the new dock, etc., it is proposed to construct a landing stage available for passenger, goods, and cattle traffic. It is to extend about 550 feet from Dumball Island, and to have a depth of 14 feet alongside at extreme low water. It will be provided with pontoons, luggage hoists, etc. The estimated cost is £85,000. A new granary is also proposed to be erected at Avonmouth, at a cost of £40,000. Four hydraulic cranes are in course of erection on the Narrow Quay. The promoters of a landing-stage at Portishead, available for large vessels, do not appear to be discouraged by the proposals of the Docks Committee, being of opinion that the two schemes, if carried into effect, would be mutually advantageous. The circumstances at Portishead appear favourable to the construction of a low-water pier. On the other hand, Avonmouth is in direct railway communication with both the Great Western and Midland systems, Portishead with the Great Western chiefly. The Docks Committee report

unfavourably of the scheme, partly on technical grounds and partly on account of the inexpediency of allowing a pier to be constructed and owned independently of the Corporation.

Bristol Floods Prevention.—I need not here refer in detail to the recent history of the floods question, and only remark that the works connected with the channel of the Frome, under the Acts of 1887 and 1890, have most of them been carried out or are in progress. In addition to the relief culvert to the Floating Harbour, these works include the removal and reconstruction of old archways of restricted dimensions; the substitution of girder bridges of increased span and height for the stone bridges at Wade Street, Lower Ashley and Mina Roads; the building of long lengths of retaining wall; the deepening of the bed of the Frome throughout, eighteen inches to three feet and upwards; and the removal of many thousands of loads of mud, stones, and refuse therefrom. A contract has recently been let for the completion of the improvement works in the Frome as far as the city boundary at Eastville. This contract includes the diversion of the river between the Gas Works Bridge and the Great Western Railway Bridge, Stapleton Road, from its present circuitous to a straight course; the removal of Baptist Mills Weir, and widening and deepening the mill stream so as to convert it into the main channel of the Frome; and other works. The aim throughout has been to make a channel of nearly uniform discharge capacity from the city boundary to the outlet to the Floating Harbour, so that at times of floods of not exceptional severity the flood water shall pass off as freely from Eastville (hitherto so liable to frequent flooding) as from Mina Road and the parts lower down the river. The Frome relief culvert has an area of a little over 100 square feet. It is built in 9-inch and

14-inch brick work (according to the nature of the ground). It has fully justified its construction by the discharge of a large volume of flood water at times of fresh in the Frome.

Black-Rock Culvert.—For some time subsequent to the flood of March, 1889, there appeared to be a general feeling in the city that the construction of this culvert should be proceeded with under the powers of the Act of 1890; but as time passed, and the effects of the flood were less strongly remembered, doubts were freely expressed as to the necessity for the large outlay, on the ground that the improved channel of the Frome would effectually provide for the discharge of flood water. At a meeting of the Town Council, at which a formal vote became necessary, the resolution to proceed was carried by so narrow a majority that the Floods Committee hesitated to act upon the resolution, and at a subsequent Council meeting it was resolved, on their recommendation, that Sir John Coode should be called in to report on the following points:—

"1st. Whether the proposed Relief Culvert from Stapleton to the Black-Rock is necessary to entirely prevent flooding from the Frome?

"2nd. If so, whether it will be effectual?

"3rd. Is it the best scheme for effecting such prevention?

"4th. Whether it can be carried out for the Parliamentary Estimates?"

Much time and care were devoted by Sir John Coode and his partners to the investigation of the subject in all its bearings, and the Report was presented to the Council in February of the present year, copies being distributed to members of the Council, and abstracts of it appearing in the local newspapers. The Report was eventually referred to the Floods Committee for a statement of their views thereon,

and the question remains in suspense until this has taken place. I must refer to the Report itself for a detailed statement of the case, only quoting the summary on its last page.

"1st. The proposed Black-Rock Culvert is necessary in order *entirely* to prevent flooding during periods of excessive rainfall, such as in March, 1889, especially when coupled with adverse conditions of tides.

"2nd. It would certainly be effectual in its operation.

"3rd. It is also the best scheme for the prevention of floods.

"4th. It can be efficiently carried out for the amount of the Parliamentary Estimates."

If it be conceded that the improved channel of the Frome will convey six million cube feet per hour and no more, without causing floods, the whole question of the necessity for a relief culvert obviously hinges on the estimated amount of rainfall within a limited time, and the amount of flood water due to such rainfall which would pass down the Frome. There is also another important consideration connected with the capacity of the Floating Harbour referred to later on. Mr. Howard and Mr. Martin, in their Reports, estimated the maximum flood discharge of the Frome at eight million cube feet per hour. This was in 1881 and 1882, since which the passage of flood-water has been accelerated by the removal of mills and other obstructions in the upper part of the Frome basin. Mr. Hawksley and Mr. Harrison Hayter, in their evidence before the Lords' Committee of 1890, estimated the rainfall at $3\frac{3}{7}$ inches in twenty-four hours, yielding eighteen to twenty-one million cube feet per hour. The late Dr. Burder, in a paper read before the Naturalists' Society last session, gave a much less estimate. My own estimate was nine to ten million cube feet per hour; and the maximum of twelve million cube feet per hour was

adopted as a desirable, if not necessary, precaution against a probable more rapid future discharge. Sir John Coode's Report estimates the present maximum discharge at eight million cube feet per hour, but adds: "As Mr. Fox has pointed out however, in designing any relief works some allowance should be made for contingencies, and I have previously called attention to the acceleration of the downward passage of the water consequent on the removal of obstructions lying in the up-stream side of the city boundary, so that in devising measures for permanent relief it would not be prudent to calculate on a smaller discharge than ten million cube feet per hour, to which an addition should be made for the effect of unfavourable tides in restricting the period when the underfall sluices would be open, and consequently reducing the discharge through the Float." Whether the very large, and (as I think) greatly over-estimated, amount of flood water, as given by Messrs. Hawksley and Hayter, or the more moderate estimate of nine to ten million cube feet per hour, be taken as correct, it is clear that if the improved Frome channel will discharge only six million cube feet per hour, any excess beyond that quantity must inevitably cause flooding. An idea has been somewhat largely entertained that the Frome floods affect only a comparatively inferior class of house property in and near Mina Road. This, however, is a great misapprehension, as the area includes Merchant Street, Newfoundland Road, Broad Weir, Nelson Street, Broadmead, with several important manufacturing and other properties therein. Hitherto it has been assumed that the six million cube feet per hour which the improved Frome channel will convey, will be freely discharged into the Floating Harbour. This, however, is subject to an important qualification. It will not be the case in certain states of the tides in the Avon, when for periods of three

hours and upwards the tide level in the Avon is higher than the Floating Harbour, and sluicing therefrom is necessarily suspended. One foot in depth over the area of the Floating Harbour represents about $3\frac{1}{4}$ million cube feet, and if flood water, at the rate of six million cube feet per hour, were poured into the Floating Harbour for three hours or more, whilst the sluices were closed, there would occur a rise in the level of nearly six feet, which would be objectionable, both as to its effect on the shipping, and the probable flooding of cellars near the Harbour. If, however, a flood of eight million cube feet should occur, and it should reach the Harbour, the variation of level would be still greater. It is true that the coincidence of the period of greatest flood discharge with that of high spring tides in the Avon is an event that might rarely occur, but the possibility of its occurrence cannot be disregarded in considering any scheme for the prevention of floods. A very valuable addition to the means for regulating the capacity of the Floating Harbour to receive and discharge flood water from the Frome, is provided by the new sluices at Cumberland Basin, constructed by the Docks Committee at a cost of about £13,000. The length of the proposed Black-Rock Culvert is a little over three miles. About two-thirds of its length would be through red sandstone and marl, with a short length of millstone grit. This part is intended to be lined with brickwork, except where harder rock may render brick lining unnecessary. The remaining third would pass through mountain limestone, and would not be brick-lined, but the surface of the excavated rock would be rendered comparatively smooth by filling hollow places with cement concrete. The discharge from the culvert would vary between $5\frac{1}{2}$ million cube feet per hour at the period of highest equinoctial tides, and $8\frac{3}{4}$ to 9 million cube feet per hour at

low tides, the total discharge in twelve hours being between 90 and 100 million cube feet. Stoney's patent sluices would be placed at the inlet at Stapleton, and self-acting gates at the outlet to the Avon at Black-Rock. The culvert, if constructed, would also provide for the interception and discharge to the Avon of the flood waters of the Boiling Wells, Cutlers' Mills, and Horfield Brooks, which now cause local flooding, independently of that arising from the Frome.

Bedminster Floods.—Parts of Bedminster are not unfrequently flooded from the water of the Malago Brook, which passes by a very tortuous course through Bedminster, to outlets to the New Cut. This brook has been greatly obstructed and its area lessened, by arches of limited span. As a remedy for the flooding from the Malago, Mr. Howard, in his report of 1883, advised the construction of a relief culvert from St. John's Road to an outlet to the New Cut opposite Gothic Cottages, and this work, together with loop culverts for avoiding parts of the archway of the Malago, known to be in a defective condition, is now being carried out. The principal culvert is 9 feet wide by 7 feet 3 inches high, having an area of about 50 square feet. It is constructed of 9-inch (and in some parts 14-inch) Cattybrook brickwork, in vertical bond. The cost of this work, exclusive of property and easements, will be about £20,000. Since a part of Bedminster is three feet or more below the level of high spring tides, a valve will be placed at the inlet to the present Malago Brook, in order to regulate the passage of flood water through the channel of the brook at times of highest tides. The main relief culvert will have sufficient head to discharge at all states of the tide. There can be no doubt that these works, when completed, will effectually prevent future flooding from the Malago.

St. Augustine Bridge. — The history of the Fixed Bridge movement is no doubt familiar to you all, and also that an Act was obtained in the session of 1891, for the bridge, archway, and filling the water space, at an estimated cost of £23,500. The contract for this work was let a few months since, and considerable progress has been made. The first work was the erection of a temporary bridge to allow of the removal of the Drawbridge and of the construction of the southern half of the new bridge, on the completion of which the traffic will be turned over it, and the remaining half of the new bridge completed, the temporary bridge being then removed. The roadway of the new bridge will be about 75 feet wide, with foot pavements on each side of 15 feet and 10 feet wide respectively. The archway for conveying the Frome to the Floating Harbour on the south side of the new bridge has a clear span of 24 feet, The arch is of Cattybrook brick, $2\frac{1}{2}$ bricks in thickness, built in vertical bond, with a proper proportion of special taper bricks. This arch is thicker than would be ordinarily necessary for an arch of the span, but as buildings may possibly be erected over it at some future time, and the crown of the arch is very near the surface of the newly-made ground, it was necessary to make it of extra strength. The invert of the archway is formed of a layer of concrete dished in the centre. The outer part of the archway towards the Floating Harbour is of a span of 30 feet, to give a better external appearance to the bridge. The face work of the abutments and the curved wing-walls is of fitted rubble below, and coursed rubble (in 12-inch courses) above water level. The quoins, voussoirs, and strings, and other dressed work are of red Wilderness stone from the Colchester-Wemyss quarries. The new roadway will be of wood paving on concrete. On the south side there will be an ornamental

iron parapet railing, between pilasters of dressed stone, which will carry standards for electric or gas lighting.

New Wharf Wall and Widened Roadway, St. Augustine's.—This wall extends from the south-west wing wall of St. Augustine Bridge, to the new wharf wall at Canon's Marsh, a length of 845 feet. It consists of a series of brick piers 10 feet 3 inches, and 18 feet apart, centre to centre, on foundations of cement concrete, about 3 feet in thickness. Between the piers are turned 18-inch brick arches, the larger arches in vertical bond. The average width added to the roadway of St. Augustine's Parade will be 28 feet. This addition, combined with the greatly increased width of, and improved access to, St. Augustine Bridge, will together form one of the greatest street improvements of recent years in Bristol.

Electric Lighting.—Bristol has hitherto been somewhat behind other cities and places of smaller population in the matter of electric illumination, but it has been determined to make a commencement, and accordingly an electric lighting station and apparatus are in course of construction at Temple Back, the former from the designs of Mr. Henry Williams, architect, and the latter under the direction of Mr. Preece, F.R.S. The site of the buildings is of an average length of 136 feet, by 96 feet wide, with a frontage on the Floating Harbour. The whole area for the buildings has been piled with larch piles at 4 feet apart, centre to centre, and of lengths varying between 18 and 36 feet, about 1,000 piles having been driven. On these, concrete is placed of different thicknesses according to the requirements for the foundations of the engines, boilers, dynamos, etc. The engines are of Willan's compound transfer system, nine in number, and of the united power of 1,200 h.p. The boilers are of steel, seven in number, of the

Lancashire type, 8 feet diameter, with two furnace tubes, each about 3 feet diameter, three of the boilers being 28 feet long, and three 24 feet long. They are to sustain a working pressure of 125 lbs. to the inch. The engines work nine dynamos or alternators. The system of electric-lighting recommended by Mr. Preece is that known as the alternate current, high pressure, transforming system, by which transformers are excited at high pressure, and the current distributed at low pressure.

Bristol Waterworks Company.—In addition to the existing large storage reservoirs at Barrow Gurney, the Bristol Water Company is constructing a new store reservoir, which is now approaching completion. It has a water area of 65 acres, and a storage capacity of 534,000,000 gallons. Another reservoir is also in course of construction near Blagdon, for impounding the head waters of the Yeo and other springs, with a watershed area of thirty-two square miles, and a capacity of 1,500,000,000 gallons. The total engine power connected with the several lifts, now amounts to 850 nominal H.P. The consumption of water per head of the population is about 23½ gallons per diem, including supply for all purposes.

Railway Communication with Bristol Quays.—More than thirty years ago, when engineer of the Bristol and Exeter Railway, I was called on to report upon a scheme for communication with the quays, as designed by Mr. (now Sir) John Fowler and Mr. Richardson, in connection with the proposed Bristol and Clifton Railway. This railway scheme was strongly opposed and fell through, and the only communication with the wharves is that of the Harbour Railway, the exclusive property of the Great Western Company. To supply this much-needed requirement in a fuller manner than is afforded by the Harbour Railway, a scheme was pro-

posed last year by an independent company, advised by Mr. Kincaid as engineeer, for an extension of the Port and Pier line to the wharves, and the Midland Company were urged to adopt and carry out the scheme. Eventually that Company withdrew from the undertaking on the ground of its great cost (estimated at £400,000). Recently another and much less costly scheme has been suggested under the engineering advice of Mr. Kincaid, and it is now understood to be under consideration by the Midland Company.

Clifton Rocks Railway.—This railway is for passenger communication between the lower level of the Hotwells and Clifton Down. It is on the funicular system, and is to be worked on the counter-balancing principle, the additional weight required being obtained from water tanks supplied with water by the Bristol Water Company. There are four sets of rails of a gauge of 3 feet, and four cars will be worked at each operation, two descending and two ascending. Each car will carry eighteen passengers. The tunnel is 500 feet long, and the inclination is one in 2·226. The width of tunnel 27 feet 6 inches, and height 17 feet. The tunnel is arched throughout with four courses of bricks in cement (separate rings), and the sides are in places lined with 18-inch brickwork, where the condition of the rock rendered it necessary. This railway is a private undertaking, at the cost of Mr. Newnes; the local engineers are Messrs. P. Munro and Son.

Municipal Buildings.—It has been manifest for some time past, that the present Council House is quite unworthy of the importance of a city like Bristol, and various sites have been proposed on which to erect municipal buildings, affording accommodation for the several public departments, instead of, as at present, their being located in different parts of the city. Property has been acquired with the view of erecting

larger municipal buildings on the present site, but there is a strong feeling that this site is both inadequate in area and awkward in regard to its plan. Other sites have been suggested, amongst which are:—1. The covered water-space above the new St. Augustine Bridge. 2. St. Augustine's Parade, opposite the new bridge. 3. The Corporation property in Baldwin Street. Each of these sites has its advantages and defects. The first offers a fine site if the warehouses on the Narrow Quay were removed, so as to give a greater area, and open out St. Stephen's Church. The second would form an imposing site, but would involve the purchase of expensive property. The third is feasible as regards cost of property as well as area, but the position is not so central. I have thought it well to mention this briefly as one of the contemplated works. The question has now been remitted to a committee of the Town Council to inquire into and report thereon.

Draught in Marine Boilers.

By J. W. I. HARVEY.

Read before the Engineering Section on March 21st, 1893.

THE author having fully explained in detail the data contained in the accompanying table, and that the results had been reduced to a standard evaporation of "from and at 212°," proceeded to draw comparisons between the various systems of draught, and remarked that—

He had been led to investigate the subject of "Draught" from a desire to ascertain if there are really any grounds upon which the advocates of forced draught are justified in claiming the economy they say attends the application of their various systems.

And whilst, on the one hand, he had the advantage of the very full and excellent reports of the carefully conducted experiments of the "Research Committee on Marine Engine Trials," instituted by the Society of Mechanical Engineers—on the other hand, similar experiments with "Forced Draught" have not been so carefully carried out or recorded; consequently the requisite data for an exhaustive comparison of the different systems have not been available. The economical aspect of the subject therefore cannot be fully discussed for want of evidence; and until similar information as that of the "Research Committee" is forthcoming from some independent source, the advantages or otherwise of "Forced Draught" must remain undetermined.

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TABLE TO ILLUSTRATE Mr. HARVEY'S PAPER ON "DRAUGHT."

Museum of Comparative Zoology
FEB 25 1942

LINE				A.	B.	C.	D.	E.	F.	G.
		Index Letter		A.	B.	C.	D.	E.	F.	G.
		Vessel		Meteor.	Fusi Yama.	Colchester.	Iona.	Torpedo.	Torpedo.	Chaser.
		Engine...		Triple.	Comp.	Twin Comp.	Triple.	Comp.	Comp.	Comp.
		Boiler		Cylindrical.	Cylindrical.	Cylindrical.	Cylindrical.	Loco.	Loco.	Loco.
		Coal		Scotch.	Newcastle.	Yorkshire.	Newcastle.	Welsh.	Welsh.	Cowpen.
		System of Draught		Nat.	Nat.	Nat.	Fan.	Cl. Stk.	Cl. Stk.	Cl. Stk.
1	Ratios—	Heating Surface to Grate Area		32·00	43·40	26·5	75·2	3·27	32·7	42·5
2	„	Tube Surface to Grate Area		27·70	32·50	21·7	61·7			
3	„	Grate Area to Tube Area		5·47	4·05	5·51	2·3			
4	„	Grate Area to Funnel Area		5·04	3·21	4·77	1·4			
5	Pressures—	Steam in Boiler	Pounds	145	56·8	80·5 .	165	117	115	125
6	„	Air in Stokehold	„				5/32=·17	2 ins.	6 ins.	3·54
7	„	Air in Funnel	„	5/16=·31	9/32=·28	11/32=·36	·25			21/32=·65
8	Temperatures—	Steam in Boiler	Degrees	363	304	324	373	348	347	353
9	„	Feed Water	„	163	129	113	106	53	56	37
10	„	Ingoing Air	„		55	55	62			75
11	„	Outgoing Gases	„	791	578	835	452	1,037	1,444	1,150
12	„	Furnace	„	3,360	2,240	2,888	2,470	3,268	4,200	3,476
13	Power—	Indicated Horse Power		1,994	371	1,980	645			
14	Coal—	Pounds consumed per Hour	Pounds	4,005	987	5,742	942	925	1,815	5,165
15	„	„ „ „ per Square Foot of Grate ...	„	19·25	18·98	26·1	22·4	49·0	96	98·4
16	„	„ „ „ „ „ „ Heating Surface	„	0·602	0·437	0·987	0·298	1·5	2·93	2·31
17	„	„ „ „ per Indicated Horse Power ...	„	2·01	2·66	2·90	1·46			
18	Water—	Pounds evaporated per Hour	Pounds	32,846	8,763	48,989	10,008	7,862	13,028	35,925
19	„	„ „ „ per Square Foot of Grate ...	„	158	168	222	238	416	689	684
20	„	„ „ „ „ „ „ Heating Surface	„	4·91	3·88	8·41	3·16	12·72	21·03	16·09
21	„	„ „ per Pound of Coal	„	8·21	8·88	8·53	10·63	8·16	7·18	6·95
22	„	„ „ per Indicated Horse Power per Hour ...	„	16·5	23·6	24·74	15·50			
23	Air—	Pounds consumed per pound of Coal	Pounds	15	23	18·5	24·5	(18)	(13)	(16)
24	Calorifics—	Thermal Units in one pound of Coal	T.U.'s	12,770	12,760	13,280	14,830	14,000	14,000	14,000
25	„	„ „ taken up per one pound of Feed Water ...	„	966	966	966	966	966	966	966
26	„	„ „ „ „ Coal	„	7,930	8,578	8,240	10,268	8,210	6,936	6,713
27	„	„ „ „ by Feed Water per minute ...	„	528,788	141,084	788,720	161,129	126,573	209,750	578,344
28	„	„ „ per Indicated Horse Power ...	„	265	380	398	249			
29	„	„ converted into Work per minute... ...	„	85,240	15,859	84,637	27,590			
30	Conductivity—Speed of Heat through each Square Foot of Heating Surface per hour		T.U.'s	4,770	3,751	8,131	3,059	12,288	20,364	15,547
31	Percentages—	Of Heat taken up by the Feed Water (Boiler Efficiency)		62	67·2	62·0	69·2	59	49	48
32	„	„ carried off by the Outgoing Gases		22	23·4	28·0	16·2	31	33	31
33	„	„ lost by Imperfect Combustion, Radiation, Ashes, etc. ...		16	9·4	10·0	14·6	10	18	21
34	„	„ used by the Engine (Engine Efficiency)...		16	11·2	10·7	17·1			
35	„	Combined Efficiency of Water and Engine		10	7·5	6·5	11·8			

Analysis of the Chimney Gases per Cent. by Volume.		Carbonic Acid.	Carbonic Oxide.	Oxygen.	Nitrogen.
	A.	12·5	0·8	5·4	81·2
	B.	6·93	0·0	12·14	80·93
	C.	9·25	0·23	10·04	80·48
	D.	8·20	0·00	11·17	80·63

Nevertheless, the following general conclusions may be drawn, to be substantiated or not as fuller information is obtained.

The conclusions he had formed from a study of these experiments are that, for maximum efficiency—

The ratio of heating surface to grate requires to be increased beyond what is now usual.

The air should be supplied by artificial means and not by chimney draught, as artificial draught commands a great advantage over natural draught, insomuch that in the former case the air supply can be and is best kept to within 1 lb. in excess of that required for complete combustion, ensuring the highest furnace temperature; whereas in the latter case an excess of as much as 100% is required to give a good chimney draught.

That air supplied under pressure has a very beneficial effect upon the rate of combustion per sq. ft. of grate. This is generally ascribed to the mechanical action of the air disintegrating the fuel, allowing the distillation of the gases, and the fretting away of the particles of carbon for admixture with the oxygen to be performed more rapidly.

That forced draught as at present applied cannot be conducive to efficiency, principally on account of the loss by the high temperature of the outgoing gases.

That any attempt to heat the ingoing air by the outgoing gases is more beneficial in the case of natural draught than in that of forced draught. The increase of efficiency in the latter case probably cannot exceed 4%, which cannot be considered commensurate with the complicated and expensive fittings required.

That with "Natural Draught" the efficiency of the boiler is limited by the loss of heat necessary to maintain the draught (25%), and that although every precaution may

be taken to reduce the other losses from radiation, incomplete combustion, etc., to their lowest practicable amount (5%), these losses cannot be eliminated altogether, and under the best conditions will generally be found to exceed 25% and 5% respectively. So that the maximum evaporative efficiency of this system of draught cannot exceed 70%, and will in general be found to be nearer 60%; and however the ratio of these losses are varied, by reducing the temperature of the outgoing gases, by extending the heating surface, or otherwise, their sum will remain fairly constant, the other losses being increased by the sluggishness of the draught and the cooling of the furnace gases.

With "Forced Draught" the losses vary within much wider limits, averaging 32% and 17% respectively, in sympathy with the intensity of the draught; so that with a pressure of two inches of water or above, the maximum evaporative efficiency is found not to exceed 59%, and will in general be found to be nearer 50%. And notwithstanding the greater advantage that this system secures in regulating the minimum supply of air, the gain is more than counterbalanced by the loss from the very high temperature of the escaping gases and the higher rate of radiation, etc., which can only be reduced by very greatly extending the heating surface, not without sacrificing one of the claims upon which its advocates rely,—namely, economy in weight and space,—and it is difficult to see how the claim for a large increase in evaporative efficiency can be substantiated, in the absence of more precise data; for granted that an economy of 4% can be secured by heating the draught by the outgoing gases, the total efficiency only amounts to 63%, or about equal to that of the worst of the natural draught boilers, and is still lower than case B by 4%.

Now having regard to the fact that neither of the foregoing systems of draught appears to satisfy the conditions necessary to maximum efficiency, which is most nearly approached by that in use with the D boiler, it appears that the best result would be obtained by some system of artificial draught, whereby on the one hand some portion of the 25% lost in the creation of natural draught, and on the other hand some of the 33% loss consequent on the high temperature of the outgoing gases in the case of forced draught, might be prevented; and that probably some system of artificial draught supplying the minimum quantity of air required for combustion, at a pressure not exceeding one inch of water, and heated by the escaping gases, combined with such an extension of heating surface as would ensure that the temperature of the outgoing gases be not much above that of the water in the boiler, would be found to give the best results in economy of consumption.

It is only left to call attention to the analysis of the outgoing gases, and to the fact that the analysis shows that the combustion in ordinary working is much more perfect than perhaps is generally supposed, as in each case the whole of the carbon has been burnt to carbonic acid, a result which few would perhaps have been willing to admit without such evidence.

The Green Woodpecker.

(*Picus Viridis.*)

By CLAUD DRUITT.

Read before the General Meeting, February 2nd, 1893.

THIS bird is the most common of our English woodpeckers. It is pretty well distributed over the midland and southern counties, and throughout Wales. There are, I believe, only two authenticated records of its capture in Ireland, and only one in Scotland.

The family of woodpeckers is, however, nowhere abundant; and most authorities seem to agree that, in the British Isles at any rate, their numbers are rather on the decrease than on the increase.

The green woodpecker has been described by some as an "awkward" bird; but I think those who have spent any time in watching its habits, will agree that this title is altogether undeserved.

No one will deny, however, that it is a *handsome* bird. The upper plumage is dull green, passing into bright yellow at the tail coverts. The outer webs of the wing feathers are prettily barred with white. The crown, back of the head, and moustache of the male bird are crimson.

The *female* is distinguished from her mate by having less crimson on the top of the head, and by the *black* moustache. From the middle of the latter gleams out the keen-sighted eye with its white iris.

The *young bird* is of a greenish ash colour, speckled and spotted with dark brown, which colour is also dispersed in bars across the breast.

I may add that the crimson colour seems one characteristic feature of the woodpecker family, and is found on some part of the plumage of almost all, if not on every species. It is certainly present in each of the six British species in both sexes.

Let us now consider in brief the structure or organization of the woodpecker, which is most wonderfully adapted to its mode of life. Its long, straight, wedge-shaped *bill* is very powerful. By it the bird is not only enabled to hack away the bark and wood of decaying trees, in order to get at the insects and other creatures lurking beneath or within, but by means of this tool also, it constructs, or rather excavates, its deep dark home within the trunk of some favourite tree. Nor are its capabilities limited to rotten or decaying wood, but, as I hope to show presently, the bill is sufficiently powerful to penetrate sound and growing timber. In addition to its bill, the bird is provided with a peculiar *tongue* of wonderful structure, especially suited to its requirements and mode of existence. It is round in shape, flattened at its tip, which is also pointed, and provided with two rows of horny barbs, projecting backwards towards the mouth. It is capable of protrusion a long distance beyond the extremity of the bill, an arrangement by which the bird is enabled to secure its prey in cavities and recesses otherwise totally inaccessible.

I should like to describe, if possible, the wonderful anatomy of the tongue of the woodpecker, in relation to the *hyoid bone*, or, as it has been well called, the skeleton of the tongue.

This bone and its cornua, or horns, may easily be felt in our own neck just above the prominence known as Adam's apple, by placing the thumb and first finger around the front part of the neck.

It is to this bone that the muscles which protrude and retract the tongue are attached.

The cornua are more elongated in birds than in mammals, and they project towards the back of the neck, being quite distinct from the skull in most cases.

In the woodpecker, however, these horns, after passing backwards on each side of the neck, curl first upwards and then forwards, and converge to meet each other at the vertex of the head. They now run in a special furrow in the bone, on the top of the skull, curl round the right orbit, and are finally attached to its inner margin. These curved bones are highly elastic, and are contained within a sheath, together with a muscle which lies on and is attached to their concave side. This muscle has also a fixed attachment to the lower mandible. Hence, when it contracts, the loop, which the hyoid bone forms in the neck, is first raised, and then carried forwards, with the result that the free tip of the tongue is widely protruded.

Sir Charles Bell states that the same muscle which causes the protrusion of the tongue, also exerts pressure on a large salivary gland, by which means a drop of highly viscid secretion is poured out on the barbed extremity of the tongue, thus enabling the bird with great ease and rapidity to convey to its mouth small insects, such as ants, which when touched by the tongue instantly adhere to it. By the simple contrivance of the muscle being placed on the inner or concave side of the loop previously spoken of, a very slight shortening of the muscle causes remarkable increase in the length of the tongue. The organ is withdrawn into the mouth again by muscular power, which action is greatly assisted by the elasticity and springing back of the prolongations of the hyoid bone. The woodpecker depends to a very large extent on its tongue for procuring

its food, and were it not for the wonderful adaptation of its structure, the bird would frequently be compelled to leave a dainty morsel, in the shape of a fat grub, unmolested within its burrow.

Whilst staying at a farm in Hampshire during last September, I heard of a practical use to which the dried tongue of the woodpecker was sometimes put; namely, for removing from the throat of young chicken the small worms which cause the disease known as "gapes." I think you will agree with me that no better instrument could possibly be devised for accomplishing a purpose so analogous to that for which it was created. We may be thankful, however, that there are simpler and more successful ways of curing "gapes" than by adopting instrumental measures, as the latter might give another excuse for depriving the woodpecker of its joyful existence.

We will now briefly consider a few other characteristic features in the structure of this interesting bird.

The *breast bone* deserves notice on account of the shallowness of its keel; so that the bird can keep its body in close proximity with the trunk of a tree, which position is necessary in climbing.

The *feet* are large in size, and are of the zygodactyl, or yoke-toed modification, *i.e.*, having two toes projecting forwards and two backwards. It was considered at one time that this was a typical climbing foot, but it cannot be so regarded now, since the same type is found in the cuckoo, which does not climb; whilst the nuthatch and tree-creeper, most expert climbers, possess the ordinary passerine foot. But, however this may be, the bird climbs remarkably well, and it is possible that the yoke-toed arrangement gives it a firmer grasp, when clinging to one spot for a length of time, as when occupied in commencing its nesting burrow.

The *tail* consists of ten stiff-pointed feathers, and is always firmly applied to the tree when climbing, thus giving great support to the spine, and enabling the bird to work with power and precision.

Let us now leave the structure, and consider some of the bird's habits.

To begin with that of *nesting*.

As is well known to all, the woodpecker builds no nest, but excavates a pear-shaped burrow, from one to two feet in depth, in the interior of the trunk of a tree. At the bottom of the burrow the female lays four or five glossy white eggs, which are more or less pointed at one end.

It has long been a disputed point whether the bird ever attacks sound as well as decayed wood for nesting purposes. Some go so far as to declare that no English woodpecker possesses a bill powerful enough to penetrate sound timber. Observation, however, shows that the bird is amply capable of accomplishing the task when any special advantage is to be gained, although it shows a marked preference for decaying trees under ordinary circumstances. It has been well said, "The aged tree is everything to the woodpecker, and the woodpecker is everything to the aged tree." This seems much more just than the following quotation: "It is a great enemy to old trees, owing to the holes which it digs in their trunks."

The first nesting hole of the green woodpecker I ever found was in a wood about eight miles distant from Clifton. I was out with a friend on an egg-hunting expedition, and I remember this as one of the most productive days we ever had together. It was on the 2nd of June, 1888. Our attention was first attracted by hearing a peculiar sound, something between a laugh and a cry, frequently reiterated. We soon espied the vociferous bird, and watched it from

some distance off, ascending, by a series of jerks, the trunk of a large oak.

It might here be remarked that the woodpecker is rarely, if ever, seen to *descend* a tree, but seems to be guided in its climbing by the motto "excelsior."

After watching for some time, the bird suddenly disappeared, and, on reaching the tree where we last saw it, we discovered a circular hole in the trunk, not more than fifteen or twenty feet from the ground. In less time than it takes to relate, we were both vigorously hammering at the tree in order to dislodge the occupier of the hole above. All in vain, however; once within her hole she would not stir, and not until a wire had been thrust down the burrow could she be forced to leave it. After the bird had made her escape, the other end of the wire, which was formed into a small bag with a piece of muslin, was passed into the nesting hole, and one by one the five eggs were withdrawn. When first taken they appeared to be mottled all over with a light brown colour, but this was in reality nothing but dirt from the bird's feet, after climbing about in wet weather and then sitting on its eggs. The colour all disappeared on washing, but I have left one egg just as it was when taken. This nest was in an oak tree, and I was much struck by the fact that the bird could excavate such a tunnel in solid and hard wood. The perseverance of the woodpecker must have been something extraordinary, and is worthy both of admiration and imitation.

I very much wished to cut down the tree, and preserve the portion containing the burrow, in order to show the skill of the bird. But as this was impossible, I did what seemed to be the next best thing. Shortly afterwards I visited the spot again, taking with me a 2-ft. saw. I ascended the tree with this, and, after working for nearly

three-quarters of an hour, succeeded in removing a wedge-shaped slice, which contained, in its centre, the entrance hole to the burrow.

Why the bird should have selected a tree whose wood was so hard, wherein to excavate its home, was to me a puzzle, as there were scores of others within a few hundred yards of the spot showing marked signs of decay, whereas this one appeared quite sound. Towards the end of last year, however, I got a partial solution to the question, when I visited the tree again, in order to submit it to a careful examination. It was still apparently healthy, bearing leaves and acorns, and this was five years after the nest had been taken. Moreover, the bark had grown for some distance over the spot where the wedge had been cut out, thus proving the vitality of that part of the tree, at any rate, through which the first part of the tunnel was bored. Finding nothing amiss with the external aspect of the oak, I climbed up in order to obtain a view of the interior, through the opening made by the conjoint efforts of the bird and the saw. On illuminating the burrow by means of a match, I perceived that the posterior wall appeared wet and partially decayed.

This showed, what I had never suspected before, that water must have gained access to the heart of the tree, and had there been doing its slow, silent, but inevitably sure work of destruction. The point at which the rain water had first gained entry was not far to seek. A yard or so above the burrow was a small dead branch, projecting almost vertically upwards. The bark around the base of this small branch formed a circular furrow, in which water naturally found a lodgment, and, in course of time, penetrated to the centre of the tree, rendering that part considerably softened. At this point the blade of a pen-knife

could be inserted. This shows that the woodpecker's task was not quite such a laborious one as it at first appeared; but nevertheless the bird had to perforate several inches of solid and healthy wood, in order to get at the softened parts within.

This explanation brings up an interesting question. Could the bird tell, before commencing its burrow, that the heart of the tree it had chosen was decaying, whilst the exterior was sound? If so, how? I believe there is only one method; viz., by *percussion*. The woodpecker is most perfect in this art, which must prove an invaluable assistance to it in many ways. Just as the carpenter uses his hammer to find where lath and plaster ends, and brickwork begins, so does the woodpecker utilize his sturdy bill, and easily detects the difference between the note produced by percussing the solid oak and that by "tapping the hollow beech tree." I ought to mention that the oak under consideration does not stand upright, and the bird made its burrow on that side which was nearest to the ground. Thus, it will be seen, no rain could enter. Does this not show something in the woodpecker near akin to reason?

It is often stated that the bird removes the discarded chips of wood from the spot where it makes its burrow; but this is by no means always the case, as they often serve as the first indication of the nest. The bird generally makes a new nesting hole every year, the old ones being used for *roosting* purposes. Standing close to a large house, not far from Clifton, there is a tree having a hole in which a green woodpecker was seen to retire regularly every evening. It has roosted there for some years, and for all I know to the contrary, still continues to do so.

I alluded just now to the pertinacity with which the bird clings to its home. I have lately come across a striking

but sad instance of this. An acquaintance of mine found a hole in a tree, and on listening heard something move inside. He came to the conclusion that the hole contained bats, and forthwith proceeded to "smoke them out." As the fumes produced no effect, he tried pouring water down the hole. This likewise was ineffectual. Being determined, however, not to be beaten by a few bats, he broke open the tree, and to his surprise and sorrow found the dead and dishevelled body of a green woodpecker.

Before concluding the remarks I have to make on the green woodpecker, I should like to say something with regard to its *food*. This consists entirely of those various forms of animal life found inhabiting decaying timber, or taking shelter beneath the bark. The stomach of a woodpecker I opened contained a large number of the common wood-louse, as well as some red ants. The bird is remarkably fond of ants, and accordingly they constitute its chief food.

M. Prevost tabulates its diet as follows:—

Jan., ants; *Feb.*, worms and grubs of ants; *March*, slugs, beetles, and grubs of ants; *April*, ants and worms; *May*, red ants and grubs of wasps; *June*, bees and ants; *July*, red ants; *Aug.*, red ants and worms; *Sept.*, ants and worms; *Oct.*, grubs of ants; *Nov.*, grubs of ants and bees; *Dec.*, ants.

This list rather reminds one of the bill of fare of the natives of India and Ceylon, whose meals consist, so we are told, of curry and rice on the six working days of the week, and for a great treat on Sunday they have rice and curry.

The green woodpecker is certainly able to find ants in the winter as well as in the summer, although in the winter season it must have considerable difficulty in obtaining them. On November 24th, 1892, during a sharp frost, I was

walking over the part of the Leigh Woods at the top of Nightingale Valley. I several times disturbed a green woodpecker from the grass. On examining a spot recently vacated by the bird, I perceived the ground was penetrated by a number of small holes, about two inches deep. These I concluded had been made by the bird, in order to obtain food, whilst around the same spot was a quantity of recent excreta, which on closer inspection was found to consist entirely of the remains of red ants.

I have lately found several young ash trees attacked by the larva of the Wood-Leopard moth. The damage done to the tree consists of a burrow, eight or ten inches in length, cut longitudinally within the trunk. Although the caterpillar leaves no trace of its work externally, its presence is soon detected, somehow, by the woodpecker, and the wily bird speedily devises a plan for its dislodgment. A funnel-shaped hole is bored through the wood until its apex opens into the insect's burrow. This being accomplished, the bird thrusts its worm-like tongue through the hole made by the bill, and then along the passage made by the grub. The barbed tip soon feels the struggling caterpillar, and by a rapid dart instantly impales it, then drags it from its hiding-place, and the bird finally demolishes it.

And now it is that "the ringing of the Whitwall's shrilly laughter, which echo follows after," is heard to the best advantage, as the bird wings his undulating flight in search of a fresh victim.

Notes on the Habits of the Larva of Gracillaria Syringella.

By H. J. CHARBONNIER.

Read at the General Meeting, October 5th, 1892.

IF we examine the lilac trees in our gardens in spring, May or June, we shall notice that some of the leaves are disfigured by being mined in large brown blotches. If we open one of these "blotches," we shall find it to be the home of from four to twelve nearly transparent, greenish white larvæ, actively engaged in eating the parenchyma of the leaf, the upper and lower cuticles of which act as floor and ceiling of their temporary dwelling.

As soon as the space between the two cuticles becomes too shallow for the growing larvæ, they change their method of working, and, passing out on the under side of the leaf, proceed to roll it upon itself, with the help of numerous silken threads, almost invariably beginning at the tip of the leaf, secure in this retreat. Feeding upon the under surface of the leaf, they take care in rolling it to preserve the form of a *loose* scroll, so that by continuing the rolling they constantly enlarge their habitation.

As the larvæ advance from the tip of the leaf, the increasing size and stiffness of the midrib become serious obstacles, to obviate which, the larvæ carefully cut notches, nearly, and sometimes quite, through the midrib. These notches are generally at fairly regular distances, nearer together at first, and becoming more distant as the size

of the scroll increases. Sometimes, though rarely, they are quite irregular. The notching is often done *previously* to the rolling, so that a leaf may be found notched down to the petiole, but only *half* rolled. In a very few instances the *side* edge of the leaf is first begun to be rolled, and the midrib not having to be rolled is *not* notched. Occasionally the leaf is rolled with its upper surface inwards, beginning at the tip, and in this case the midrib is duly notched.

When the leaf has been sufficiently rolled, the ends of the roll are neatly fastened together with silk.

When full fed the larva lets itself down to the ground by a silken thread, too often, alas! into the jaws of some foraging ant, to be carried off as "provisions" to the formicary.

Besides allowing of the free rolling of the leaves, the "notches" afford strong points of attachment for the silk threads.

I have since observed the same larvæ on "privet," and the midribs of the leaves are notched in the same manner as those of the lilac.

The insect in all its stages is most admirably described in "Stainton's Natural History of the Tineina."

ABSTRACT.

The Coloration of Cuckoos' Eggs.

By JOHN ALEXANDER NORTON, M.D.

Read at the General Meeting, November 3rd, 1892.

A PAPER was read upon the questions whether the coloration of birds' eggs is protective, and why the cuckoo selects those nests in which she deposits her eggs.

Passages were quoted from Seebohm, some of which were written by Mr. Dixon, upon which Mr. Seebohm says, "This chapter has been written for me by Mr. Charles Dixon, and is sufficiently elaborate to post my readers up in the questions which have arisen on this subject, since it has been regarded from the evolutionist point of view. The results of the investigation are not quite so satisfactory as might have been expected. There are so many cases which cannot be explained by protective selection, that the student not being able in this instance to fall back upon sexual selection, is obliged to assume that many effects are the results of extinct causes."

The study of the cuckoo and her habits should show protective selection, if there is such a thing among birds.

What is the meaning of extinct causes as a factor in Nature?

For the study of Oology birds' eggs have been divided into two great classes, solely according to whether they are spotted or white (or self-coloured), and these are sub-divided as to whether they are laid in open or covered nests.

Following these, there appears to be no constant rule, the exceptions to any attempted or artificial rule being almost as many as the observances. And the evolutionist asks us to suppose that the earliest eggs were white, and that colour is a development for protective purposes! Where is the evidence of change in type of eggs?

The cuckoo deposits her eggs in all sorts of nests, not simply those of insectivorous birds, as has been said, though all nestlings are insectivorous or flesh-eaters (except the pigeons among British birds),—if she makes use of pipits, warblers of many sorts, larks, flycatchers, swallows, wrens, butcher-birds, wagtails, thrushes, and grebes' nests, we should expect to have the eggs placed in the right nests as to the colour of the eggs; but we find nothing of the sort.

The bird has no control over the colour of her egg, and to suggest protective selection is an extraordinary assumption; for what is the influence of the male bird upon the colour of the shell of the egg laid by his mate? And further, does the bird know anything about the colour of the egg that his mate will lay so that he can select? The hen bird certainly knows nothing of colour, for her eggs are deposited in many nests,—that is, the same cuckoo does not deposit all her eggs in one sort of nest; if she exercised any powers of thought, this would not be the case. It is suggested that a bird having successfully deposited in one nest would in future years make use of a similar nest, but there is no evidence to show that the bird takes any observations as to the results of her choice of nest. A single cuckoo egg is often found alone in a nest, the only egg of the foster-parent having been ejected; where is there evidence of the egg having been deposited so that the foster-bird should not notice it? Two cuckoo eggs in one nest are most often of different types, though not invariably so. This appears as

if the bird does not recognise any difference between her own egg and that of the foster-bird.

The cuckoo does not exhibit any intelligence in her selection, often depositing her egg in a nest from which the grown young cannot escape; she merely exercises an instinct which has taught her not to make a nest for herself, but to make use of some other nest, and she deposits her egg in the one nearest to hand.

There can be no doubt that the colour of some eggs is protective, but there is no evidence that the types of eggs are showing any alterations, and many eggs are not, according to human reasoning, coloured protectively, or laid in the best sort of nests.

A collection of British eggs, and a large series of cuckoos eggs, with, in most cases, the eggs of foster-parents, was shown in proof of the above.

Reports of Meetings.

GENERAL.

THE past session has not been marked by any unusual features. The usual eight meetings have been held, and some excellent papers have been read.

On Thursday, October 6th, 1892, Mr. H. J. Charbonnier exhibited a stuffed specimen of the spotted flycatcher of a light-grey colour. He then gave an account of the life-history of a moth (*Gracillaria syringella*), and described the method by which the grub rolls leaves to form its home. A digest will appear among the "Proceedings." Mr. Percy Leonard then read a paper entitled, "The Natural History of the Downs."

At the meeting held November 3rd, Dr. J. A. Norton exhibited a stuffed specimen of an albino swallow, and then read a paper in which he set himself to answer the following questions: "Is the coloration of birds' eggs protective?" and "Why does the cuckoo select those nests in which it deposits its eggs?" A large collection of eggs were exhibited to illustrate the paper.

On December 1st, Dr. Shingleton Smith read a paper entitled, "The Structure, Function, and Preservation of the Skin." Diagrams and microscopical sections helped to explain the various points raised in the reading of the paper.

The usual exhibition was held January 12th. The mem-

bers who brought objects of interest briefly explained and commented upon their exhibits. Miss A. P. Fry exhibited some ferns from Madagascar, and a crocodile's egg. Mr. G. C. Griffiths exhibited a collection of Lepidopterous insects, sub-family Danainæ. Mr. Percy Leonard exhibited a live slow-worm. Prof. Leipner exhibited a collection of economic seaweeds. Mr. C. R. Rudge exhibited some specimens of British Echinidæ and other marine animals. Mr. Edwin Wheeler exhibited four volumes of paintings of British Fungi.

On February 2nd, Prof. Leipner exhibited a specimen of *Lycopodium squamatum*, the "Resurrection Plant." Mr. H. J. Charbonnier exhibited a stuffed specimen of the skylark, a buff variety; also a nest of *Myrapetra scutellaris*, a small wasp from tropical America. Mr. Claud Druitt then read a paper on "The Green Woodpecker." A number of stuffed specimens and sections of branches illustrated his remarks.

At the meeting held on March 2nd, Mr. G. C. Griffiths read a paper entitled, "Some Remarkable Insects." Some very rare and beautiful specimens were handed round. Mr. C. R. Rudge exhibited a specimen of the lantern fly.

On April 4th, Mr. Claud Druitt exhibited some live specimens of the great warty newt, the palmated newt, and the common smooth newt. Dr. A. B. Prowse then read a paper entitled, "Some Ancient British Remains on Clifton Down." Numerous photographs were shown to illustrate his paper.

At the meeting held on May 4th, which was the thirty-first Annual Meeting, the reports of the Honorary Secretary, the Treasurer's report and Balance Sheet, and the Librarian's report were read, and the officers for the ensuing season were appointed. Prof. Lloyd Morgan then gave the Presidential Address, entitled, "Early Man in the South-west of Eng-

land." Various slides were thrown upon the screen, consisting of maps, plans, pictures of animals, etc.

The meetings have all been held at the University College.

H. PERCY LEONARD,
Hon. Reporting Secretary.

BIOLOGICAL SECTION.

DURING the winter our members held several meetings, at which papers were read and specimens shown by Mr. Budgett, the President, and the Secretary. Botanically, the discovery by Mr. Read of a new station for *Menyanthes* on the Somerset side of Bristol, has been the most noteworthy incident.

JAS. W. WHITE, *Hon. Sec.*

CHEMICAL AND PHYSICAL SECTION.

DURING the past session four meetings have been held at University College, and papers have been read by the following gentlemen: Prof. S. Young, Prof. A. P. Chattock, Mr. W. A. Shenstone, Mr. C. R. Beck, Mr. G. L. Thomas, Mr. F. B. Fawcett, and Dr. Richardson.

The number of members and associates is thirty-seven.

ARTHUR RICHARDSON, *Hon. Sec.*

ENGINEERING SECTION.

FIVE meetings were held during the Session 1892–3. The following papers were read: "Local Engineering Works in Progress or Contemplated," Mr. Francis Fox; "A Method of Marine Engine Investigation as applied to Testing a series of Screw Propellers," Mr. W. G. Walker; "Two

American Clutches," Mr. Thomas Morgans; "Tensional Weakness under Heat exhibited by certain cheap $\frac{3}{4}$-inch Bolts," Mr. Thomas Morgans; "Draught in connection with Consumption of Fuel," Mr. J. W. I. Harvey (President).

NICHOLAS WATTS, *Hon. Sec.*

ENTOMOLOGICAL SECTION.

AT the indoor meetings no papers of importance have been read, but large numbers of species have been exhibited by different members, including many rare and some new and undescribed species.

Two outdoor excursions were taken by the section last summer, in May to the neighbourhood of Dursley, and later to the moors near Glastonbury. In both cases the weather proved not very favourable, and the list of species seen and captured was not of a kind to need special notice. At the Annual Meeting a small balance in hand was reported, and no change in officers was made.

GEO. HARDING, *Hon. Sec.*

GEOLOGICAL SECTION.

ONLY one excursion has been made by the section during the past year, and there has been only one ordinary meeting.

CHARLES JECKS,
Acting Hon. Sec.

The following Publications of the Bristol Naturalists' Society may be obtained from any Bookseller, or from the Honorary Secretary.

One Volume, bound, 5s.

FLORA OF BRISTOL.

By James Walter White, F.L.S.

The area of this flora is that included in the geological map of the Bristol coal field, by the late William Sanders, F.R.S., F.G.S.

The Fungi of the Bristol District. By Cedric Bucknall, Mus. Bac.

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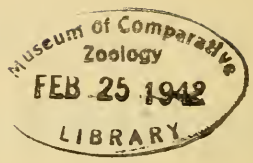

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Yours sincerely
John Burroughs

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Dr. Beddoe,

F.R.S.

JOHN BEDDOE was born September 21st, 1826, at Bewdley, in Worcestershire, of a family settled in Shropshire for many generations, but derived, it is said, from an old Powysland stock, the fifth royal tribe of Wales. He was educated at Bridgnorth School, then flourishing under the Rev. Thomas Rowley, D.D., and after some years of enforced idleness from ill health, entered at University College, London, in 1848. In 1851 he took the B.A. degree of London, and next year the First M.B.. examination. Growing appalled, however, at the long vista that stretched before him towards the M.D. Degree of London, he removed to Edinburgh, where he graduated M.D. in 1853, his thesis being "On the Geography of Phthisis."

In 1853, too, he first directed his attention to Anthropology, and published his first paper on the subject, "A Contribution to Scottish Ethnology." After a short time spent in University College Hospital, he returned to Edinburgh, where he was successively house-physician under Andrew, and house-surgeon under Spence.

After good service in Turkey during the Crimean War, he returned to Europe in 1856, travelled in Germany, spent a winter in the hospitals of Vienna, and a spring in Hungary, Italy, etc., and then settled down to practise as a physician

at Clifton, where he has till lately been located. He held the physicianship to the Bristol Infirmary for eleven years, and is still consulting physician to the Bristol Dispensary and to the Bristol Children's Hospital. He has also been president of the Bristol Naturalists' Society, of the Bristol and Gloucestershire Archæological Society, and of the Bristol and Bath Branch of the British Medical Association.

Of his medical writings, the most notable are a paper on Hospital Dietaries, reprinted from the *Dublin Journal*, in which he treated the subject from the economical and from the physio-chemical points of view, and one on the comparative mortality of England and Australia. He wrote the article on "Mortality" for Quain's Dictionary, and two Presidential Addresses on Public Health—one statistical, for the local Medical Association—the other suggestive, for the Health Section of the Social Science Association, at its Edinburgh meeting.

Dr. Beddoe was an office-holder in the Ethnological Society, and contributed papers to its transactions; but he early joined the Anthropological Society on its foundation by James Hunt, and was its president for two years. More recently he has held the same post in the Anthropological Institute. He was also for several years a member of Council of the British Association, in which he attached himself chiefly to the Geographical and Statistical Sections, and it was partly owing to his exertions, aided by those of Sir William Turner and the late Allen Thomson, that anthropology assumed a permanent position in the organisation of the Association.

In 1873 he was elected a Fellow of the Royal Society, and in the same year became a Fellow of the College of Physicians. He is an honorary member of the principal foreign Anthropological Societies. His published papers in

this department of science are too numerous to catalogue: they have appeared, for the most part, in the Memoirs and Journal of the Anthropological Society, in those of the Ethnological Society, of the Anthropological Institute, and of the British Association, and in the Revue d'Anthropologie.

In 1868 Dr. Beddoe carried off the great prize (150 guineas) of the Welsh National Eisteddfod, for a MS. Essay on "The Origin of the English Nation." The prize had been competed for during five years by a large number of competitors, the judge being the late Lord Strangford. During seventeen years the author continued to add to his materials, visiting for that purpose almost every part of the United Kingdom, until, in the autumn of 1885, he published the condensed results under the title of "The Races of Britain: a Contribution to the Anthropology of Western Europe." The work was very warmly received, and favourably reviewed by the organs of scientific thought in Germany, France, Belgium, and America. Whatever its merits or defects, it is undoubtedly the most elaborate and comprehensive work of the kind in any language.

He is LL.D., *honoris causâ*, of the University of Edinburgh, a Life Governor of University College, London; and has received from the French Government the First Class of the Order of Public Instruction. In 1891 he was Rhind Lecturer in Archæology, and delivered in Edinburgh a course of Lectures on the Anthropological History of Europe.

Dr. Beddoe took a most active part in the work of the Bristol Naturalists' Society, as will be seen by the following list of the papers he has read from time to time at the General Meetings:—

Nov. 6th, 1882. "The Physical Characters of the Natives of this District."

Dec. 3rd, 1863. "The Maori, or New Zealand Race."

March 5th, 1868. "The Methods of Measuring the Human Body for Ethnological and other purposes."

March 4th, 1869. "The Typical Races of Mankind."

June 6th, 1870. "The Natural History of Frenchmen."

Jan. 5th, 1871. "The Natural History of the Germans."

April 4th, 1872. "On the Anthropology of the Danubian Region."

March 6th, 1873. "Ethnic Migrations."

Nov. 2nd, 1876. "The Anthropological Aspects of the War in the East."

Dec. 4th, 1879. "The Ethnology of the Paropamisus" (Afghanistan, etc.).

Phenological Observations for 1893.

PLANTS.

Recorders: Miss Annie Baker, Bridgwater (A.B.); Mr. L. W. Rogers, 2, King's Parade, Clifton (L.W.R.).

Abbreviations.—App., first appearance above ground; Bud b., first buds bursting; Fol., almost in full foliage; Fl., first flower; R. fr., first ripe fruit.

1. *Anemone nemorosa* (Wood Anemone).—Fl. March 8th, Combe Dingle; abundant, L.W.R.

2. *Ranunculus ficaria* (Pilewort, Lesser Celandine).—App. Jan. 27th, by 8th, Hamp, A.B.; March 5th, Combe Dingle; abundant, L.W.R.; Fl. March 8th, Combe Dingle; abundant.

3. *Ranunculus acris* (Upright Crowfoot).—App. Feb. 3rd, by 7th Hamp, A.B.; March 8th, Combe Dingle, abundant, L.W.R.; Fl. April 23rd, Combe Dingle, with bulbosus and auricomus, L.W.R.

4. *Caltha palustris* (Marsh Marigold).—App. Mar. 22nd, Markham Bottom, L.W.R.; Fl. April 3rd, Boiling Well, L.W.R.

5. *Papaver rhœas* (Red Poppy).—Fl. May 24th, Cossington, A.B.; by June 28th, Sea Mills, L.W.R.

6. *Nasturtium officinale* (Watercress).—Fl. May 13th, Weston in Gordano Marshes.

7. *Cardamine pratensis* (Cuckoo-Flower).—Fl. March 25th, Markham Bottom, L.W.R.; April 8th, by 6th, Canal, A.B.

8. *Alliaria officinalis* (Jack-by-the-hedge).—App. Feb. 3rd, by 7th, Hamp, A.B.; March 8th, Combe Dingle, L.W.R.; Fl. April 4th, by 1st, Hamp, A.B.; April 11th, Black Rock Quarry, L.W.R.

9. *Draba verna* (Whitlow Grass).—App. Feb. 1st, Gully, Clifton Down, L.W.R.; Fl. February 12th, Gully, Clifton Down, L.W.R.; R. fr. March 24th, Gully, Clifton Down, few plants, plenty by 31st, L.W.R.

10. *Viola odorata* (Sweet Violet).—Fl. March 12th, Combe Dingle, white, L.W.R.

11. *Polygala vulgaris* (Milkwort).—Fl. by May 6th, Dundry, abundant, L.W.R.

12. *Lychnis diurna* (Red Campion).—Fl. March 13th, Durleigh, A.B.; April 12th, under Cook's Folly, L.W.R.

13. *Stellaria holostea* (Greater Stitchwort).—Fl. March 9th, Durleigh, A.B.; March 25th, near Pill, L.W.R.

14. *Cerastium pumilum* (Mouse-ear).—Fl. Feb. 19th, Gully, few plants, abundant by March 20th, L.W.R.; April 7th, Hamp, A.B.

15. *Malva sylvestris* (Common Mallow).—App. Jan. 25th, by 10th, Hamp, A.B.; by March 30th, Black Rock Quarry, L.W.R.; Fl. May 13th, Weston in Gordano, with rotundiflora, L.W.R.

16. *Tilia parvifolia* (Small-leaved Lime).—Bud b. March 25th, Clifton Down; April 3rd, Whiteladies Road, L.W.R.; Fol. April 12th, Whiteladies Road, L.W.R.; Fl. June 6th, Whiteladies Road, L.W.R.

17. *Hypericum perforatum* (Perforate St. John's Wort).—Fl. May 13th, by 2nd, Durleigh, A.B.; June 8th, Sea Mills, Mr. Mole (F.R.C.S.); with hirsutum, L.W.R.

18. *Hypericum pulchrum* (Upright St. John's Wort).—Fl. June 8th, Sea Mills, Mr. Mole (F.R.C.S.).

19. *Geranium Robertianum* (Herb Robert).—App. Feb. 7th, Hamp, A.B.; March 15th, Black Rock Quarry, L.W.R.; Fl. April 6th, Black Rock Quarry, L.W.R.; April 27th, Durleigh Road, A.B.

20. *Euonymus Europœus* (Spindle-tree). — Bud b. March 10th, Proctor's Fountain, L.W.R.; Fol. April 18th, Proctor's Fountain, L.W.R.; Fl. April 29th, Proctor's Fountain, L.W.R.; R. fr. Oct. 23rd, Proctor's Fountain, pods burst, L.W.R.

21. *Acer pseudo-platanus* (Sycamore).—Bud b. March 10th, Proctor's Fountain, L.W.R.; March 18th, Taunton Road, A.B.; Fol. March 25th, Proctor's Fountain, L.W.R.; Fl. April 29th, Proctor's Fountain, L.W.R.; R. fr. Aug. 27th, Proctor's Fountain, nearly over, L.W.R.

22. *Æsculus hippocastanum* (Horse Chestnut).—Bud b. March 8th, Sneyd Park; flower buds, March 15th, L.W.R.; March 11th, by 2nd, Hamp, A.B.; Fol. April 6th, Sneyd Park, L.W.R.; April 16th, Hamp, A.B.; Fl. April 15th, Sneyd Park, L.W.R.; Apr. 15th, Hamp, L.W.R.; R. fr. Aug. 30th, Long Ashton, L.W.R.

23. *Cytisus laburnum* (Laburnum).—Bud b. March 10th, Apsley Road, L.W.R.; March 11th, by 1st, Taunton Road, A.B.; Fol. April 1st, Sneyd Park, L.W.R.; Fl. April 22nd, Apsley Road, L.W.R.; R. fr. August 7th, Apsley Road.

24. *Trifolium repens* (Dutch or White Clover).—Fl. May 22nd, by 7th, Durleigh, A.B.; May 27th, Sea Mills, L.W.R.

25. *Lotus corniculatus* (Bird's-foot Trefoil).—Fl. May 8th, Hamp, A.B.; April 22nd, Black Rock, L.W.R.; April 18th, Mr. Mole.

26. *Vicia cracca* (Tufted Vetch).—Fl. June 25th, L.W.R.

27. *Vicia sepium* (Bush Vetch).—Fl. March 20th, Black Rock, all scorched up without seeds, L.W.R.; April 7th, Hamp, A.B.

28. *Lathyrus pratensis* (Meadow Vetchling). — Fl. April 22nd, Hamp. A month earlier at Hamp than at Durleigh, A.B.; May 13th, Weston in Gordano, L.W.R.

29. *Prunus spinosa* (Sloe, or Blackthorn).—Bud b. March 15th, Gully, L.W.R.; March 25th, Woolavington, A.B.; Fol. April 7th, Downs, two trees with flowers and foliage, L.W.R.; Fl. March 14th, Durleigh, A.B.; March 24th, Gully, L.W.R.

30. *Spiræa ulmaria* (Meadow Sweet).—App. May 12th, Weston in Gordano, L.W.R.; Fl. June 14th, Keynsham, Mr. Mole.

31. *Potentilla anserina* (Silver-weed).—App. March 28th, by 10th, Hamp, A.B.; March 29th, opposite Sea Mills, Mr. Mole; Fl. April 23rd, Combe Dingle, L.W.R.; April 25th, by 3rd, Hamp, A.B.

32. *Rosa Canina* (Dog Rose).—Bud b. Feb. 23rd, Durleigh, A.B.; March 8th, Proctor's Fountain, L.W.R.; Fol. March 30th, Road, A.B.; March 31st, Proctor's Fountain, L.W.R.; Fl. April 27th, Downs, Miss Bainbrigge; May 12th, by 7th, Enmore, A.B.; R. fr. Sept. 2nd, Downs, fully ripe, L.W.R.

33. *Pyrus aucuparia* (Mountain Ash, or Rowan).—Bud b. March 16th, Apsley Road, L.W.R.; Fol. April 1st, Apsley Road, L.W.R.; April 17th, Ashley Hill, L.W.R.; R. fr. June 26th, Whiteladies Road, L.W.R.

34. *Pyrus aria* (White-beam).—Bud b. March 16th, Gully, L.W.R.; Fol. April 16th, Downs, L.W.R.; Fl. June 5th, Downs, L.W.R.

35. *Cratægus oxyacantha* (Hawthorn).—Bud b. Feb. 24th, by 3rd, Taunton Road; March 10th, Downs, L.W.R.; Fol. March 25th, Downs, general by March 30th, L.W.R.; Fl. April 7th, Taunton Road, A.B.; April 14th, Worle Hill, Mr. Muskit (Weston); April 19th, Black Rock, L.W.R.; R. fr. July 25th, Downs, L.W.R.

36. *Epilobium hirsutum* (Great Hairy Willow-herb).—App. April 22nd, Sea Mills, L.W.R.; Fl. May 29th, by 1st, Canal, A.B.; Fl. June 14th, Keynsham, Mr. Mole.

37. *Epilobium montanum* (Broad Willow-herb).—App. May 6th, Dundry, L.W.R.; Fl. May 8th, Downs (garden); May 29th, Canal, A.B.; R. fr. June 2nd, Downs (garden), L.W.R.

38. *Angelica sylvestris* (Wild Angelica).—Fl. May 27th, Markham Bottom, L.W.R.; R. fr. Aug. 30th, Long Ashton.

39. *Daucus carota* (Wild Carrot).—Fl. June 25th, Black Rock, L.W.R.; R. fr. July 27th, Black Rock, L.W.R.

40. *Hedera helix* (Ivy).—Fl. Aug. 30th, Long Ashton, L.W.R.; R.

fr. Feb. 19th and Nov. 27th, Sea Walls, L.W.R.; Mar. 30th, Petherton, A.B.

41. *Cornus sanguinea* (Dog-wood).—Bud b. March 10th, Downs, L.W.R.; April 7th, by 10th, Hamp, A.B.; Fol. April 18th, Downs, L.W.R.; Fl. May 5th, Sea Mills, Mr. Mole; May 18th, Downs, L.W.R.; R. fr. Aug. 13th, Downs, L.W.R.

42. *Adoxa moschatellina* (Moschatel).—App. March 8th, Combe Dingle, in bud, L.W.R.; Fl. March 20th, by 1st, Broomfield, A.B.; March 25th, Markham Bottom, L.W.R.

43. *Syringa vulgaris* (Lilac).—Bud b. March 5th, Apsley Road, L.W.R.; Fol. March 30th, Apsley Road, L.W.R.; April 12th, St. Mary Street, A.B.; Fl. April 9th, Apsley Road, L.W.R.; white before purple, April 16th, by 2nd, St. Mary Street, A.B.

44. *Galium aparine* (Cleavers).—App. April 29th, Pur Down, L.W.R.; Fl. April 28th, Keynsham, Mr. Mole; May 8th, by 3rd, Hamp, A.B.

45. *Galium verum* (Yellow Bedstraw).—App. April 18th, Downs, L.W.R.; Fl. June 6th, Downs, L.W.R.; July 14th, by 3rd, Wembdon, A.B.

46. *Dipsacus sylvestris* (Wild Teasel).—App. March 8th, Combe Dingle, L.W.R.; Fl. July 15th, Black Rock, L.W.R.

47. *Scabiosa succisa* (Devil's-bit).—Fl. Aug. 30th, Long Ashton, L.W.R.; July, Scotland, Mr. Mole.

48. *Petasites vulgaris* (Butterbur).—App. April 14th, Crew's Hole, with leaves 8 in. to 10 in. broad, L.W.R.; Fl. March 15th, Portbury, C. Bucknall.

49. *Petasites fragrans*.—Fl. Feb. 2nd and Nov. 7th, Black Rock, abundant, L.W.R.; Dec. 17th, by 7th, Hamp, A.B.; Fol. Mar. 7th, Black Rock, L.W.R.; Dec. 18th, Hamp, A.B.

50. *Tussilago farfara* (Coltsfoot).—Fl. Feb. 20th, Black Rock, abundant by March 7th, L.W.R.; Fol. March 15th, Black Rock, many small leaves, L.W.R.

51. *Achillea millefolium* (Yarrow).—App. Feb. 3rd, Hamp, A.B.; March 22nd, Tan Pits, N.c., L.W.R.; Fl. April 27th, by 3rd, Durleigh Road, A.B.; June 25th, Black Rock, L.W.R.

52. *Chrysanthemum leucanthemum* (Ox-eye).—App. March 22nd, Leigh Woods, L.W.R.; Fl. April 29th, Leigh Woods, L.W.R.

53. *Artemisia vulgaris* (Mugwort).—Fl. July 30th, Sea Mills, L.W.R.

54. *Senecio Jacobæa* (Ragwort). — App. March 30th, Downs, L.W.R.; Fl. June 25th, Black Rock, L.W.R.

55. *Centaurea nigra*.—Fl. June 14th, Keynsham, Mr. Mole.

56. *Carduus lanceolatus* (Spear Thistle).—Fl. May 29th, Canal, A.B.; June 23rd, Downs, L.W.R.

57. *Carduus arvensis* (Field Thistle).—Fl. May 29th, Canal, A.B.; June 22nd, Montpelier, L.W.R.

59. *Hieracium pilosella* (Mouse-ear Hawkweed).—Fl. April 30th, Downs, L.W.R.

60. *Campanula rotundifolia* (Hairbell).—Fl. May 19th, St. Mary Street, A.B.; July 9th, Downs, L.W.R.

61. *Ligustrum vulgare* (Privet).—Fl. May 22nd, by 2nd, Durleigh, A.B.; June 5th, Downs, L.W.R.; R. fr. Nov. 20th, Downs, L.W.R.

62. *Convolvulus sepium* (Greater Bindweed).—Fl. June 25th, Sea Mills; June 22nd, my garden, L.W.R.

63. *Symphytum officinale* (Comfrey).—Fl. April 22nd, Keynsham, seeds formed, Mr. Mole.

64. *Pedicularis sylvatica* (Red Rattle).—Fl. May 27th, Markham Bottom, L.W.R.

65. *Veronica Chamœdrys* (Germander Speedwell).—App. March 15th, Black Rock, L.W.R.; Fl. March 30th, Black Rock, L.W.R.

66. *Mentha aquatica* (Water Mint).—Fl. Aug. 30th, Long Ashton, L.W.R.

67.—*Thymus serpyllum* (Wild Thyme).—Fl. July 10th, Downs, L.W.R.

68. *Prunella vulgaris* (Self-heal).—Fl. May 21st, Hamp, A.B.

69. *Nepeta glechoma* (Ground Ivy).—Fl. March 13th, Durleigh, A.B.; March 22nd, Bill Road, abundant, L.W.R.

70. *Lamium galeobdolon* (Archangel).—Fl. March 28th, opposite Sea Mills, Mr. Mole; May 12th, by 4th, Spaxton, A.B.

71. *Stachys sylvatica* (Hedge Woundwort).—Fl. May 13th, Weston in Gordano, L.W.R.; May 22nd, by 2nd, Durleigh, A.B.

72. *Ajuga reptans* (Bugle).—Fl. April 12th, Black Rock, L.W.R.; April 27th, Durleigh, A.B.

73. *Primula veris* (Cowslip).—Fl. March 18th, Dunball, A.B.; March 31st, Long Ashton, Mr. Mole.

74. *Plantago lanceolata* (Ribwort Plantain).—Fl. April 8th, Petherton Levels, A.B.; April 19th, Sea Walls, L.W.R.

75. *Mercurialis perennis* (Dog's Mercury).—App. Feb. 20th, Proctor's Fountain, L.W.R.; March 5th, Westbury, male and female, L.W.R.

76. *Ulmus montana* (Wych Elm).—Bud b. April 6th, Downs, L.W.R.; Fol. April 22nd, Downs, L.W.R.; Fl. Feb. 26th, Downs, L.W.R.

77. *Salix caprea* (Great Sallow).—Bud b. March 22nd, Leigh Woods, L.W.R.; Fol. April 20th, Leigh Woods, L.W.R.; Fl. March 7th, opposite Sea Walls, L.W.R.

78. *Fagus sylvatica* (Beech).—Bud b. April 16th, Westbury, L.W.R.; Fol. and Fl. April 18th, Coombe Down, male and female, Mr. C. Bucknall.

79. *Corylus avellana* (Hazel).—Bud b. March 5th, Westbury, L.W.R.; Fol. April 21st, Proctor's Fountain, L.W.R.; Fl. Feb. 4th, Proctor's Fountain, male and female, L.W.R.

80. *Orchis maculata* (Spotted Orchis).—Fl. May 13th, Weston in Gordano.

81. *Iris pseud-acorus* (Yellow Iris).—Fl. May 16th, Goathurst, A.B.; May 22nd, Pensford, Mr. Mole, L.W.R.

83. *Galanthus nivalis* (Snowdrop).—Fl. March 8th, Combe Dingle, one plant near cottage, L.W.R.

84. *Scilla nutans* (Bluebell).—Fl. April 2nd, Combe Dingle, abundant, L.W.R.; April 2nd, Durleigh, A.B.

INSECTS.

Recorders: Mr. G. C. Griffiths, Clifton (G.C.G.); Mr. C. Bartlett, Redland (C.B.).

Abbreviations.—App., first appearance; G.c., getting common.

1. *Cicindela campestris* (Tiger-beetle).—App. March 29th, Leigh Woods, several, C.B.

2. *Melolontha vulgaris* (Cockchafer).—App. May 4th, Clifton and Redland, two at gas lamps, C.B.; May 4th, Clifton Down, G.C.G.

3. *Rhizotrogus solstitialis* (Fern or Small Chafer).—App. May 23rd, Brockley, C.B.

6. *Lampyris noctiluca* (Glow-worm).—App. April 3rd, Brockley, three ♀ s, C.B.

7. *Meleo prescarabæus* (Oil Beetle).—App. April 3rd, Brockley, common, C.B.

11. *Chrysomela polita.*—App. Feb. 25th, Westbury Park, C.B.

13. *Cocicnella bipunctata* (Lady-bird).—App. March 31st, Clifton, G.C.G.; April 24th, Sneyd Park, C.B.

15. *Vespa vulgaris* (Wasp).—App. March 22nd, Leigh Woods, G.C.G.; March 28th, Knowle, C.B.

17. *Pieris rapæ* (Small Garden White or Cabbage Butterfly).—App. March 12th, Clifton and Henbury, C.B.

18. *Pieris napi* (Green-veined White Butterfly)—App. April 26th, Bitton, C.B.

20. *Anthocaris cardamines* (Orange-tip Butterfly).—App. April 3rd, Leigh Woods, one specimen: a very early record, G.C.G.; April 10th, Westbury, C.B.; G.c., April 20th, Hallen, C.B.

21. *Epinephile janira* (Meadow-brown Butterfly).—App. May 22nd, Dursley, C.B.; May 22nd, one specimen only, G.C.G.

23. *Amphidasys prodromaria* (Oak Beauty Moth).—App. March 8th, Westbury, C.B.; March 18th, Leigh Woods, only one specimen seen, G.C.G.

24. *Tephrosia crepuscularia* (Small Engrailed Moth).—App. March 18th, Leigh Woods, C.B.; April 3rd, Leigh Woods, one specimen; I next found it April 19th, but these two were the only specimens met with this season, G.C.G.

25. *Tæniocampa gothica* (Hebrew-character Moth).—App. March 8th, Westbury, C.B.; March 21st, Leigh Woods, common, G.C.G.; G.c. March 21st, Leigh Woods; common at Sallows, C.B.

26. *Tæniocampa instabilis* (Clouded Drab Moth).—App. March 21st, Leigh Woods, one specimen. This and the three following species were to be found about a fortnight after this date, G.C.G.; March 21st, Leigh Woods, abundant.

27. *Tæniocampa stabilis* (Common Quaker Moth).—App. February 27th, Clifton, one specimen only, G.C.G.; March 21st, Leigh Woods, abundant, C.B.; G.c. March 21st, Leigh Woods, G.C.G.

28. *Tæniocampa cruda* (Small Quaker Moth).—App. March 2nd, Leigh Woods, abundant, C.B.; G.c. March 21st, Leigh Woods; very abundant at Sallows, G.C.G.

29. *Tæniocampa munda* (Twin-spot Moth).—App. March 11th, Redland Green, at light, C.B.; March 21st, Leigh Woods, one specimen, G.C.G.

30. *Brephos parthenias* (Orange Underwing Moth).—App. March 5th, Leigh Woods, an unusually early record, G.C.G.; March 18th, Leigh Woods, common, C.B.; G.c. March 11th, Leigh Woods, in fair abundance, G.C.G.

31. *Diurnea fagella*.—App. March 17th, Clifton. This species was to be found for about three or four weeks from this date in Leigh Woods, but was scarcely so abundant as usual, G.C.G.; March 21st, Leigh Woods, C.B.

MISCELLANEOUS.

1. *Frog Spawn*.—App. February 28th, Sea Mills, C.B.

BIRDS.

Recorder: Lewis Rogers.

One martin seen, April 16th.

Cuckoo heard, April 17th.

Pair of nightingales heard and seen at Sea Mills, April 22nd.

The unusually warm weather of the early spring led to some remarkably early emergences of the Lepidoptera; in fact, nearly all the species were three weeks or a month before their usual time of appearance. The effect of this early spring and of the great summer heat which followed was that spring larvæ were early in hatching and rapid in growth, with the result that some species, usually single brooded, became double-brooded or partially so, whilst species normally double-brooded, in several cases perfected their third brood. The end of the season was somewhat disappointing, as larvæ were by no means abundant, whilst the greater portion of the imagines were over before the autumn months. I captured a fine female specimen of our local hook-tip, *Drepana sicula*, on the 23rd May, this being the earliest date on which the species has been recorded in England. From her I obtained some ova, and was fortunate in rearing the larvæ, which pupated about the middle of July. As some of the hook-tips are double-brooded, I thought it possible that some moths from these pupæ might emerge in the autumn, and on the 16th October I bred a male, this being, I believe, the only instance of an autumn emergence in this country, though the species is double-brooded on the Continent.

Notes on Meteorological Observations at Clifton College for the Year 1893.

(230 Feet above Mean Sea Level.)

By D. RINTOUL, M.A.

1.—TEMPERATURE AND PRESSURE.

January.—The mean temperature was 35·98°, as against 39·15°, the average of the previous ten years; the month being thus much colder than usual. The first fortnight was extremely cold, the mean temperature being below the normal for the first 18 days, and even the maximum temperature was below the usual mean temperature for the first 15 days. The lowest temperature on the ground was 13° on the 3rd, and in the screen 17·70° on the 5th. There was frost on the ground on 24 days out of the 31.

February.—The mean temperature of the month was 1·66° higher than usual, being 42·04°, against the normal value of 40·38°. The temperature was higher than usual for the first three weeks, except on the 5th, 6th, and 12th; but the last week was much colder than usual. The highest temperature reached was 56·3° on the 19th and 20th, and the lowest on the ground 25° on the 25th. There was frost on the ground on 10 days.

March.—The mean temperature was 47·16°, compared with the average value of 41·65°, thus showing an excess of

5·51°. In the very beginning of this month there commenced the long period of exceptionally warm weather which will long make the year 1893 memorable meteorologically. The mean daily temperature fell below its normal value on only one day—the 19th. From the 18th of this month till the 11th of April the daily range of temperature was very great, amounting on the average to about 25° or more between day and night temperature. This was due to the prevalence of an anti-cyclonic system with easterly and northerly winds. The highest temperature recorded was 65·3° on the 29th, and the lowest 25·6° on the 19th. There was frost on the ground on 10 days.

April.—In this month the excess of temperature was more marked than in any other, amounting to nearly 7°—53·69° against 46·74°. This high temperature was most noticeable in the latter half of the month. The highest temperature recorded was 79·5° on the 21st, and the lowest 30·7° on the 14th. This latter was the only occasion on which the ground temperature fell as low as freezing point. As in March, the difference between day and night temperatures was very great, being as much as 29° on the 25th.

May.—The mean temperature for this month was 57·50°, as compared with the normal value, 52·38°, thus showing an excess of 5·12°. The mean daily temperature *never* once fell below the normal; but the highest temperature recorded fell short of the maximum for April, being 78·3° on the 5th. The lowest temperature on the ground was 39·2° on the 8th, the lowest air temperature being 40·8° on the same day.

June.—The mean temperature was 62·37°, as compared with the normal value of 58·98°. The mean daily temperature fell slightly below the normal on three days. The hottest period extended from the 13th till the 21st, and the

highest temperature recorded was 86·1° on the 18th. The lowest ground temperature was 41·2° on the 1st.

July.—The temperature this month was again above the average, though not to the same extent as in the preceding months. The mean temperature was 62·82°, being 1·78° above the normal. This excess was due mainly to the first nine days, the rest of the month being about the same as usual. With the rainy period, beginning on the 9th, the temperature became nearly normal, and at the same time the great difference between night and day temperatures disappeared, and from the 9th onwards the temperature was remarkably steady. The air temperature was highest on the 1st—83 1°—and lowest on the 2nd—47·8°.

August.—This month again showed a much higher temperature than usual—64·78°, as compared with 60·24°, the normal August temperature. For the first week the conditions were the same as for the latter part of July; but a period of very hot weather began on the 8th and lasted till the 20th. During the last week the temperature was nearly normal. The highest temperature was 86·5° on the 15th, and the lowest air temperature 47·3° on the 28th.

September.—The temperature during this month presented few features of interest. The mean temperature for the month was only a third of a degree higher than the normal. The highest temperature was 73·8° on the 6th, and the lowest temperature of air 42·2° on the 21st, and on the ground 36·7° on the 24th.

October.—The mean temperature was 50·69°, being 1·84° above the average. It was about normal for the first 12 days, then there was a period of warm weather from the 13th till the 22nd. The variations from day to day in the latter part of the month were considerable, but, on the whole, this period was also warmer than usual. The highest

temperature was 63·3° on the 21st, and the lowest on the ground 25° on the 31st. There was frost on the ground on the mornings of the 30th and 31st.

November.—This month was much colder than usual, in fact it was the coldest month of the year, with the exception of January. The mean temperature was 41·61°, as compared with the normal 44·23°, thus showing a defect of 2·62°. There were warmer periods about the 3rd, the 16th, and at the end of the month. The highest temperature recorded was 56·1° on the 16th, the lowest on the ground 24·2° on the 1st. There was frost on the ground on 17 days.

December.—The mean temperature was 41·88°, being 2·3° above the average. The daily temperature never fell below the average from the 4th till the 28th, but for the first three and last two days of the month the weather was colder than usual. The highest temperature recorded in the shade was 55·8° on the 13th, and the lowest temperature on the ground 22·4° on the 2nd. There was frost on the ground on nine nights.

1893 TEMPERATURES.

MONTH.	Maximum in Shade.		Minimum in Shade.		Mean in Shade.	Minimum on Ground.
	Highest recorded.	Mean.	Lowest recorded.	Mean.		
January .	54·3	39·96	17·7	32·00	35·98	12·9
February .	56·3	46·47	28·4	37·61	42·04	25·0
March . .	65·3	55·63	29·2	38·69	47·16	25·6
April . .	79·5	64·24	32·5	43·14	53·69	30·7
May. . .	78·3	65·84	40·8	49·16	57·50	39·2
June . .	86·1	70·84	44·2	53·90	62·37	41·2
July. . .	83·1	69·56	47·8	56·19	62·88	50·0?
August .	86·5	72·03	47·3	57·53	64·78	43·5
September	73·8	63·09	42·2	50·94	57·01	36·7
October .	63·3	55·82	29·5	45·56	50·69	25·0
November	56·1	46·13	29·1	37·08	41·61	24·2
December.	55·8	46·64	22·6	37·12	41·88	22·4
Year 1893.	86·5		17·7		51·46	12·9

Year 1892.	79·5	53·71	17·3	42·21	47·96	14·9
Year 1891.	79·1	54·59	15·2	42·70	48·64	15·2
Year 1890.	76·0	55·16	19·1	43·40	49·28	17·2
Year 1889.	80·5	55·22	22·2	43·60	49·41	18·2
Year 1888.	79·1	54·19	22·3	42·74	48·45	18·0
Year 1887.	82·8	56·0	20·4	40·9	48·4	11·7
Year 1886.	83·5	54·90	21·7	43·17	49·03	15·3
Year 1885.	87·8	53·98	22·1	42·53	48·09	20·1
Year 1884.	87·5	57·44	22·6	44·07	50·66	23·7
Year 1883.	82·5	54·54	20·9	42·88	48·71	19·3
Year 1882.	78·5	55·46	21·9	43·62	49·54	20·6

MONTH.	Number of Days on which the Minimum Ground Temperature was below 32°F.	Number of Days on which the Minimum Air Temperature was below 32°F.	Number of Days on which the Maximum Air Temperature was below 32°F.	Number of Days on which the Mean Air Temperature was below 32°F.
January . .	24	16	4	9
February. .	12	5	1	1
March. . .	11	3	0	0
April . . .	1	0	0	0
May . . .	0	0	0	0
June . .	0	0	0	0
July . . .	0	0	0	0
August . .	0	0	0	0
September .	0	0	0	0
October . .	2	1	0	0
November .	14	8	0	0
December .	10	5	0	2
Year 1893 .	74	38	5	12
Year 1892 .	91	62	11	27
Year 1891 .	83	57	8	20
Year 1890 .	79	57	16	31
Year 1889 .	88	45	5	12
Year 1888 .	93	60	2	16
Year 1887 .	148	63	2	11
Year 1886 .	102	64	1	22
Year 1885 .	68	40	1	6
Year 1884 .	51	19	0	1
Year 1883 .	79	40	0	6

MEAN SHADE TEMPERATURES OF THE MONTHS.

MONTH.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	Mean of last Thirteen Years.
January . .	42·3	44·2	38·7	35·5	41·5	38·5	37·2	43·8	35·8	37·1	35·98	39·15
February .	43·3	42·3	44·0	35·8	41·0	36·1	39·0	38·7	42·0	38·9	42·04	40·38
March . .	37·0	44·9	41·7	40·1	39·9	38·6	41·5	44·7	39·6	37·6	47·16	41·65
April . . .	47·5	45·1	46·7	46·4	42·2	44·1	46·1	47·3	44·9	47·5	53·69	46·74
May . . .	49·9	53·3	47·0	52·2	45·5	52·5	55·8	54·9	50·0	54·3	57·50	52·38
June . . .	57·2	59·8	58·4	58·8	62·4	57·9	61·3	57·5	60·1	58·1	62·37	58·98
July . . .	57·2	60·7	62·6	62·7	63·9	58·4	61·1	59·1	59·9	59·6	62·88	61·04
August . .	60·6	64·5	57·5	59·1	60·4	59·3	59·2	59·4	58·3	61·1	64·78	60·24
September .	55·3	59·4	54·5	58·2	53·7	57·3	56·9	59·7	58·7	55·6	57·01	56·68
October . .	49·6	48·9	45·6	52·9	46·1	48·8	48·8	51·3	50·3	45·4	50·69	48·85
November .	42·8	41·6	43·3	47·1	41·2	47·2	46·7	44·9	42·8	43·8	41·61	44·23
December .	41·4	43·1	38·8	38·6	39·9	42·7	39·4	30·1	41·3	36·7	41·88	39·58
The Year .	48·7	50·7	48·1	49·0	48·4	48·45	49·41	49·28	48·64	47·97	51·46	49·16

II.—RAINFALL.—MONTHLY SUMMARY.

Month.	Rainfall in Inches.	Dr. Burder's Average, 38 Years.	Clifton College Average, 11 Years.	Departure from latter Average.	Number of Rainy Days.
January .	2·105	3·212	2·491	— 0·386	10
February.	4·543	2·213	1·757	+ 2·786	23
March. .	0·635	2·252	2·082	— 1·477	8
April . .	0·067	2·117	1·986	— 1·919	2
May . .	1·290	2·399	2·190	— 0·900	10
June . .	1·261	2·551	2·346	— 1·085	9
July . .	4·265	3·051	3·607	+ 0 658	15
August .	2·388	3·410	2·939	— 0·551	10
September	1·802	3·238	3·117	— 1·315	12
October .	5·735	3·561	3·644	+ 2·091	21
November	2·390	3·050	3·304	— 0·914	15
December	2·818	2·834	3·065	— 0·247	17
Year	29·299	33·888	32·528	— 3·229	152

From the above Table it will be seen that the year 1893 was somewhat drier than usual, the deficiency amounting to over three inches. The only months in which the rainfall was above the average were February, July, and October.

There was a period of drought extending over the months of March, April and May. From the 17th of March till the 17th of April no measurable quantity of rain fell. On the latter day there was a fall of one-twentieth of an inch, and from that time till the 15th of May the rainfall amounted to only ·032 inches—*i.e.*, less than one-thirtieth of an inch. Thus, from March 17th to May 15th, a period of nearly two months, the whole rainfall amounted to only ·082, or less than one-tenth of an inch. This prolonged drought, along with the prevailing high temperature in the same period, form a very remarkable feature in the weather of 1893.

D. RINTOUL.

On the Coleopterous Genus (or sub-genus) Ceroglossus.

By EDWYN C. REED, of Santiago, Chile, Honorary Member of the Bristol Naturalists' Society.

CEROGLOSSUS may be taken as a sub-genus for the species of *Carabus* found in Chile, or as a distinct genus, closely allied to *Carabus*.

But few species were known to the old authors, the first species being described, I believe, by Fabricius, from the Straits of Magellan, as *C. suturalis*; then came another by Eschscholtz, *C. chilensis*; Laporte described a species as *C. buqueti*, which Guérin appears to have taken for *C. chilensis, Esch.*, though it is very distinct.

At the time of the publication of Gay's *Historia de Chile* (1849), Solier only admitted three species, and formed the genus *Ceroglossus* for them. Lacordaire, in 1854, refused to accept *Ceroglossus* as a genus, though it is admitted by later authors.

Afterwards Hope described some species, and Gerstaecker drew up a monograph of the known species, describing some new ones.

In 1874 I published a list of our species in the Proceedings of the Zoological Society, and described two new ones, to which I afterwards added a third, bringing up the num-

ber of known species to fourteen. In this list I was assisted by my lamented friend the late H. W. Bates, who was considered as an authority on the *Carabidæ*, and Baron Chaudoir, the highest Continental authority on the family, looked over my *Ceroglossus* and did not differ from my views.

Since that period a large number of species have reached Europe, and there are now at least fifty described species or varieties in collections.

The geographical centre of the genus may be taken as the western slope of the Andes, about latitude 40° S.; to the north of 35° S. specimens rarely occur, though I described *C. colchaguensis* from a single specimen found in latitude 34° S. The southern limit of the genus is Tierra del Fuego, two or three species reaching the Straits of Magellan (lat. 54° S.).

Though some few species occur near the coast, the greater number are found in the central plains and on the skirts of the Andes, in woods, under decayed logs and stones. There is no evidence to show if species exist on the eastern slopes of the Andes, as those regions are scantily inhabited, and, as far as I know, have never been visited by entomologists.

The reason of our sudden increase of species of late years is easily explained. In 1873 I vainly attempted to induce a guide to accompany me to the foot of the Andes, in the province of Valdivia, because that part of the country was then in the hands of the Araucanians, who objected to visitors, or, as the man whom I tried to persuade to accompany me put it, the Indians objected to let visitors leave them—*alive*. But last year I visited the whole of that part of the country in perfect safety, only accompanied by a couple of cavalry soldiers, for form's sake, while inspecting the invasion of Argentine locusts.

The march of civilization and the extension of railways

have, during the last ten years, opened up all the beautiful country round Villa-Rica, which, settled by the Spaniards some 200 years ago, was the scene of severe fighting and a general massacre shortly afterwards, and remained in the power of the Indians till quite recently, when it was settled without bloodshed.

With regard to the described species of *Ceroglossus*, I can hardly form a definite opinion on their number and merits, from want of specimens of many of the supposed species. There is endless variation in the fifty specimens that I have in my cabinets. If we judge by colour the species are infinite, but as far as form and structure go I can hardly find more than half a dozen species.

C. suturalis is a good and distinct species, and has the most southern range.

C. buqueti is well separated from most species by the coarse punctation on the underside of the thorax, and represents a large group of forms that may be varieties, as I believe, or species, as many authors state. These forms exist most commonly towards the coast, and are rare on the mountain slopes.

C. Valdiviæ is generally larger than *buqueti*, which it approaches in form, but has the underside of thorax perfectly smooth.

C. gloriosus has three or four series of minor, interrupted strigæ between the suture and the first elevated line on the elytra.

C. chilensis, with its blue thorax, is easy to recognise in typical specimens, but I have lately seen several forms that I consider as colour varieties, but that are described as species.

C. psittacus and several forms resembling it have a velvety surface to the elytra.

All the Chilian specimens of *Ceroglossus* that I have seen come under one of these forms; but as many have been described in Germany that I have not seen, I am not in a position to pronounce upon their importance, and can only add that I have been utterly puzzled by many specimens that I have seen without being able to examine at leisure; but the specimens in my collection, after a patient examination, resolve themselves into the species or groups of species mentioned above.

A collector once assured me that the specimens of any one locality agreed closely in form and colour, while a few miles away another form would exclusively appear. This may be partially true, but I have taken three species, *buqueti*, *gloriosus*, and *Valdiviæ*, under logs together.

In certain groups of insects individual variation seems to be the rule rather than the exception in this country. One morning I took some dozen specimens of a Geometron at rest on tree-trunks, evidently one species, but no two specimens exactly alike, and I could cite many similar cases. A beetle, *Corynetes ovatus*, Solier, varies immensely: over fifty well-marked varieties of this species exist in my collection.

Surveying in Unexplored Countries. The Johore Survey.

(*Abridged Paper.*)

By A. WHARTON METCALFE, Assoc. M. Inst. C.E.

SURVEYS undertaken in civilized countries differ in the methods by which they are carried out from those executed in lands uncivilized and unexplored. In the former case there are many and different methods of attaining the desired end; the choice of any one method depends chiefly upon the degree of accuracy required, and upon such considerations as rapidity of execution, economy, and convenience. In the latter case circumstances often make it desirable to resort to simple methods; as triangulation, etc. are impracticable in an unknown country thickly covered with jungle: the method of traversing is therefore usually adopted.

Traversing upon land may be defined as the art of determining the length and direction of the sides of a rectilinear polygon, following the line of the proposed works or routes of communication; the polygon may be closed or unclosed, but in a new country it would usually be the latter. The methods adopted for engineering and land surveys in open country are various; thus we have the chain survey, theodolite surveys, compass surveys, planetable surveys, as well as theodolite and compass traverses. In the Abyssinian Campaign trian-

gulation and traverse methods were combined, a triangulation being made of those portions of the country which required to be surveyed in considerable detail, such portions being afterwards connected by traverses. The Johore Survey is the record of a traverse made for the purpose of locating a proposed line, and estimating the cost of a railway from Johore Bahru to Segamat, the most southern and northern towns respectively in the territory of Johore, Malay Peninsula.

Passing on to the consideration of the instruments used in surveying and exploration, they include :—

1. Those used in the determination of latitude.

2. Those used in the determination of longitude, either by direct astronomical observation, or by taking the difference between Greenwich and local time with chronometers or rated watches.

3. Compasses and theodolites, or similar instruments, for taking bearings of the route and of prominent objects contiguous to the route.

4. Pedometers or passometers for roughly determining distances.

5. Instruments for determining height above sea level as with thermometers, by boiling, with aneroids or barometers, or with an engineer's spirit-level for exact work. Aneroids are not always reliable, as they are erratic in their behaviour. Some most valuable observations upon them may be found in Mr. E. Whymper's "Explorations in the Great Andes of South America."

Besides instruments, and equally important, are the nautical almanack for the current year, one or more copies of which should be provided.

With regard to the relative merits of chronometers and rated watches, it may be observed that the latter are pre-

ferable, inasmuch as chronometers are too delicate, on account of the nature of their escapement, to be dependable when subjected to jolting or vibration, as in transit over rough ground.

The success of exploration must necessarily depend, in the first place, upon the nature of the country and the disposition, number, and degree of civilization of its inhabitants; secondly, upon the skill, pluck, endurance, and health of the skilled staff engaged on the exploration; thirdly, upon the number and character of the natives attached to the expedition, upon whom one is dependent for the carriage of supplies, for labour, and for expert knowledge of the country traversed. An equally important matter is the possession of means for coping with disease, and with discontent or disaffection amongst the rank and file, upon whom so much depends.

A capacity for making friends with the natives of a country may also much facilitate progress, as it may enable the surveyor to glean local and other information, often of the most valuable kind—a fact which the various members of the Johore Survey staff had ample opportunity of verifying.

The Johore Survey.

Johore, an independent State, is the southernmost territory of the Malay Peninsula, having, unlike those which constitute the Straits Settlements, no British Resident. Johore is under British protection, but only in so far that, in return for services rendered in the past to the British Government by H.H. the Sultan of Johore, and on account of its strategical value, the British Government undertakes to protect the territory in case of an invasion by any foreign power. The State of Johore is separated from Singapore Island by a strait about one mile in width at its narrowest

part. Singapore Island is about 30 miles from east to west by 14 miles from north to south. On the southern side is Singapore, the commercial emporium of Malaysia. The island is crossed by a good road, and good roads intersect its cultivated parts generally; the uncultivated portion of the interior is covered by jungle, and the coast is lined by mangrove swamps.

The strait between Singapore Island and Johore formed, before the rise of Singapore City, the highway for ships bound from the West or the Straits of Malacca to the China Sea or the Central or Eastern Malay Archipelago. The island of Singapore was originally a part of the territory of Johore, but passed into British possession under Sir Stamford Raffles, sometime Governor of the Straits, who acquired the sovereign rights over the island for the British Government by purchase. The trade of Singapore with all parts of the world is very large. The Malay Peninsula itself, on the other hand, is only just beginning to be developed, and a through line from Rangoon to Johore would be a great advantage to every State concerned in the commercial prosperity of the Peninsula, as well as to Burmah and those countries bordering on Burmah.

The Malay Peninsula.

The Malay Peninsula extends from its most southern point, Johore Bahru, in lat. 1° 30′ North, to a parallel passing through the mouth of the Menam River near Bangkok. The level of the land is low in the south, but rises as you proceed northward; indeed, in many parts of the country there are mountain chains, the positions of which are not as yet, however, determined, or only approximately so. The first range, about 30 miles north of Johore, is the Blumat range. It consists of a cluster of isolated peaks which

derives its name from the most important mountain in it, Gunong Blumat. North-east of the Blumat range is the Tenang range, and north-west of this the Ophir range, which lies partly in Johore and partly in Penang.

The territory of Johore, and indeed most of the Peninsula, is at present only cultivated for a few miles inland from the coast. Here and there clearings are found, and settlements cultivated by Chinese or by Malays less civilized than those in the coast towns; but the rest of the country is covered by one vast jungle, extending from Johore to far beyond the confines of Siam, where at length severer climatic conditions begin to tell upon and to restrict the rankness of vegetable growth.

About the foot of the various mountain chains, and occasionally in the jungle, tracks of morass and swamp are met with, which present great difficulties to the progress of surveyors.

The temperature ranges from about 78° to 90°, but stands generally about 85° during the day, all the year round. There is no defined rainy season; the months which are wet one year may be dry the next. It rains nearly every day, and thunder-storms are frequent and violent. The climate is very malarious. Nearly every one suffers, sooner or later, from fever, which thins out the coolie population on the plantations to an enormous extent, the ravages of malaria being seconded by the poorness of their food and their indifference to exposure.

The inhabitants of the Malay Peninsula are various, the bulk of them being Chinese. Next in point of number come the Malays, of various kinds. There are also a number of Klings and Tamils from the south-east coast of India.

The natives of the western and central portion of the Archipelago, including parts of Sumatra, as also the in-

habitants of Madagascar, are classified as Malayo-Caucasian, or Indonesians; they are lighter in colour, taller, and better looking than the Malayo-Papuan inhabitants of the eastern Archipelago. Besides these, there are the Malays of the Peninsula, or true Malays, with which the members of the Survey Staff had chiefly to deal. In the interior, in the jungle, are tribes of jungle men, known in some places as Jacoons, in Johore as Oran Outans, and as Sakis in Pahang. These tribes wander from place to place, living in trees, feeding upon roots and such game as they can destroy with their blowpipes. These people, sometimes known as Negritos, flee upon the approach of civilized man, though they can be approached through their desire to trade. Coloured marbles and beads are the gifts most acceptable to these jungle people. The Jacoons resemble in some respects the Veddahs of Ceylon; they suffer very severely from leprosy. Mr. H. Lake, the mining engineer and explorer of the expedition, met with instances of Negritos who had lost hands, feet, and features from this disease.

The products of Johore are gambier, pepper, tea, coffee, various fruits and rice. Tin and gold, derived from washings, are worked for by the Chinese, who can make a living where Europeans would starve. Mining enterprise in the Peninsula is, however, for the present almost at a standstill, though it will doubtless be revived again.

The flora of the Peninsula is varied, orchids and creepers abounding. Only on one occasion, however, did the author see orchids in bloom, and then they were at the top of a lofty tree, which he had not time to fell.

The fauna is, if possible, more varied than even the flora, and covers every branch of the animal kingdom.

The Survey Staff comprised the Chief Engineer, Mr. F. G.

Slessor, M.Inst. C.E., late Chief Engineer of the Cape Government Railways, two District Engineers, Messrs. Page and Phillimore, 1st class assistants Messrs. Woodburn and Metcalfe, 2nd class assistants Messrs. Scoones and Ormerod. Mr. Feilding acted as secretary to the expedition, which was joined later by Mr. Harry Lake, who undertook the exploring and mining. Upon arrival at Johore, where the staff was most luxuriously housed at the Istana Tambutan, a survey was made of the town, the terminal station at Johore fixed upon, the site for the Johore-Singapore Bridge determined, and the survey begun towards Segamat.

While the chief engineer was engaged in conferences with the Government officials and in arranging the plan and details of the expedition, the district engineers were determining sites for structures and directions for lines, the assistants being engaged in surveying and levelling and, on arriving at headquarters after the day's work was over, in plotting.

When the survey work had been completed about Johore and to a distance in the direction of Segamat that could be conveniently worked, the next stage of the Survey was entered on.

Included in the preparations at Johore was the provision of a number of jungle-cutters, without whom a survey in the Malay Peninsula would be an impossibility.

The staff was then divided into two divisions, a northern and a southern, Mr. Phillimore with Messrs. Woodburn and Ormerod being appointed to the northern or Segamat division, Mr. Page with Messrs. Metcalfe and Scoones to the southern division.

The northern division was to run the traverse southward, towards Johore Bahru; while the southern division ran their traverse to meet the other. The two portions of

the traverse were to meet at a point to the east of Gunong Blumat.

Southern Division.

Towards the end of April the southern or Johore division entered into camp at Tampoy hut, five miles from Johore, from which point the traverse was worked southward and northward—southward to join with the three completed miles from Johore, and northward towards Blumat.

The southern division remained at this camp seven weeks, during which time a great deal of work was completed in the way of traverse, longitudinal section and cross-sections, the district engineer undertaking the traverse work, the first-class assistant the long section, the second-class assistant the cross-section work, each and every one having, however, to undertake the work of the other in the event of illness or absence of any one of the staff. The same division of labour was followed in the case of the northern division.

On the 11th of June, camp was moved to thirteen miles from Johore, which was situated, like the former one, on the trunk road running from Johore northwards; from the camps cuts were made to enable the engineers to reach the main jungle cut, in which the traverse line was located. The general bearing of the traverse line was 40° west of north.

After six weeks at the thirteenth mile camp, a shift was made to the twentieth mile camp, and after four weeks there to the twenty-sixth mile camp, which latter was situated in the dense jungle, where probably no civilized human being had been before.

After four weeks at the twenty-sixth mile camp, and after establishing a camp at thirty miles on the northern bank of the Syong River, the southern division returned to head-quarters, to complete the plotting of the work up to date,

as Messrs. Page and the writer having stayed over the period which the completion of the survey was expected to take, desired to return to England.

At twenty-nine miles a bad swamp was met with, over which a corduroy or faggot-bundle road had to be completed before any progress could be made, the ponies which the southern division had hitherto been able to use having to be discarded at that point. It must not be supposed that the survey was executed with the ease that the written record might lead one to suppose. Among the incidents of the survey are included disaffection and strikes among the jungle-cutters, great heat, heavy rains, laborious work through inconceivably thick jungle and undergrowth, and excessive weariness, besides the depressing effect of the gloom and solitude of the jungle, and the eternal drip, drip, drip, by day and by night, of water from the trees, arising from the condensation of the heavy and malarious jungle mists.

The engineers' camps, like most other inhabited structures in the Peninsula, were built upon piles. For, owing to the presence of malaria, it is necessary, in order to avoid the effects of the teluric poison to which malaria is due, to raise the dwelling several feet above the ground. A night spent on the ground in the jungle of Johore, like a night spent in the Terai of India, would probably prove fatal in its consequences.

The Chinese boys who accompanied the southern division proved most faithful, and were in every way excellent servants. The jungle-cutters, after they began to understand that their pay was certain and that they would be properly dealt with, and, moreover, that their places might be taken by others, did their work in a fairly satisfactory way.

Many of the chain-men and jungle-cutters proved them-

selves to be both quick and intelligent, and ready to anticipate one's wishes. It must, however, be understood that, generally speaking, the Malay cannot be depended upon for hard work, as he is by nature indolent, fond of companionship, and a lover of bright colours, which he cannot display to advantage in the jungle. The Javanese and Kalantans make good jungle-cutters and chain-men; they do not, however, care to go far into the jungle for reasons given above, and there were signs of defection and actual desertions so soon as the expedition got beyond the limits of civilization.

To turn to the northern division, to which many of the above remarks apply. Soon after the southern division had entered camp, the northern division, with Mr. F. G. Slessor, Mr. Garland, Commissioner of Public Works, and a staff of servants and chain-men, proceeded by the yacht *Pantie* to Muar, on the west coast, thence up the Muar River by launch, and then by sampans and on foot to Segamat. At Segamat they were to meet with the jungle-cutting contractor and his men, who had contracted to cut the jungle-track for the traverse line from Segamat southwards towards Johore.

Having determined the astronomical position of the starting point, and the true bearing of the initial line, the traverse line was run south until the middle of October, when the northern division returned to headquarters soon after the southern division. The hardships undergone by the northern division and the difficulties encountered by them were much greater than in the case of the southern division, their isolation being almost complete. Thus, for instance, it took ten days for communications to reach the northern division, while the southern division could at any time receive word within two days from their base of operations the headquarters at Johore.

After Mr. Page and the writer had returned to England, and after the work on the plans had been completed up to the middle of October, the northern division, increased in number by the addition of Mr. Douglas Scoones, resumed work at the thirtieth mile camp, where the southern division had left off, and from that point they extended the southern end of the traverse until it joined in with the northern end, the junction being most satisfactory.

The traverse being thus completed, the southern division returned to headquarters, to complete the plotting of the work, the preparations of the plans, sections, and drawings, and other work necessary to enable the Engineer in Chief to draw up his report. The writer has briefly sketched the proceedings of the Johore Survey Expedition; for though this paper may seem unnecessarily long, it is not long enough to adequately deal with the work done by the Johore Survey staff, in which term the writer includes Mr. Harry Lake, who did a large amount of exploration work. It is to be hoped that when Mr. Lake, who was in England recently with H.H. the Sultan, finally returns to England, he will see his way to reading a paper before the Royal Geographical or some other Society upon the exploring work and work on Boundary Commission which he has done since 1890.

Concluding remarks.—The writer fears that the remarks which he is about to make may appear to be somewhat abrupt and dogmatic; he, however, disclaims all intention of dogmatising where he only wishes to advance an opinion, which he might find later to be erroneous. With regard to the use of instruments, he believes it would be preferable to use telemeter and levels fitted with distance wires in the place of the ordinary theodolite, level, and chain; the use of which would result in economy both in time and

labour, by which also speed of progress would be attained. On the other hand, it should be remembered that whatever the speed of the staff, that speed must naturally depend upon the speed of the jungle-cutters.

From a consideration of the foregoing remarks one is inclined to think that, in cases similar to that of the Johore Survey, it would be advisable to send out some person acquainted with either the country to be surveyed or ones similar to it, to report upon the best general direction for a line of traverse, and who upon instructions received would undertake the cutting of the jungle-track, upon the completion of which an engineering staff could be sent out to rapidly execute the work of traversing. In the case of the Johore Survey, however, there were difficulties in the way of adopting such a course.

For cross-section work in the jungle, there is no doubt that the theodolite is a better instrument than the level. Large instruments should be avoided, $2\frac{1}{2}$-inch and 4-inch theodolites, or telemeters of Troughton's pattern, or of the Metford pattern, are best adapted for jungle work, especially if fitted with double microscopes and micrometers in the place of verniers. Englishmen have not as yet taken much to them, but Messrs. Troughton say that those who have done so prefer them to verniers. Though a great deal more might be said on this head, space does not permit of it.

Before concluding, the author would like to place upon record the fact that the kindness and hospitality of H.H. the Sultan of Johore, as, indeed, of every member of the Johore Government, whether native or English, will always be pleasantly remembered by each and all of the Johore Survey staff.

The author wishes, in conclusion, to record his thanks to his friend Mr. Douglas Scoones for the loan of his survey

map, on which is plotted the traverse, and also a great deal of entirely new matter, including many topographical corrections arising from the Survey made by the Staff and from the exploration work carried out by Mr. Lake during 1891.

Discussion.

At the usual monthly meeting of the Engineering Section of the above Society at University College, Bristol, on Tuesday evening, the adjourned discussion on the paper on "Surveying in Unexplored Countries,—The Johore Survey," by Mr. A. Wharton Metcalfe, Assoc.M.Inst.C.E., was resumed, Mr. Thos. Morgans, C.E., in the chair. The topographical and descriptive portions of the subject having been fully dealt with on the previous occasion, the discussion turned on technicalities and resolved itself into a consideration of recent improvements in surveying methods and instruments.

Mr. Metcalfe, at the request of the Chairman, then read a brief supplementary paper on Tacheometry and Telemetry.

The author, in opening, remarked that before a body of engineers it was not necessary to define the theodolite or level, or to go into the question of the elementary principles underlying their construction, which were obvious enough; but that he would assume that all present were more or less acquainted with the general construction of those instruments. Tacheometry and telemetry might be considered as the art of measurement of distance by means of telescopic observations on vertical graduated staves, or staves of known length: as in distinction to the usual methods of measurement by means of the chain, or by angular observations and chain combined. Tacheometers and telemeters were the instruments by which the above purposes were best accomplished. It was obvious to any one

who would take trouble to think the matter over and to plot a few lines that such measurements might be made with the ordinary theodolite by taking two observations on a staff and two angles; but on account of the number of observations entailed, the risk of personal error was so greatly increased that the method did not recommend itself except in very exceptional cases. The author proposed, for the sake of convenience, to draw an arbitrary line between tacheometers and telemeters. Tacheometers he should describe as instruments embodying the principles of Porro's lenses, though in a simpler form of the analatic lens. Telemeters, on the other hand, might be described as instruments in which an arm of known length, carrying a microscope moving on a horizontal scale, was attached to the trunnion of a telescope, the axis of the arm being perpendicular to the axis of the telescope. The scale referred to has, as regards its length and sub-division, a certain ratio to the length of the staff.

It would be easily seen, on consideration, that the movement of the telescope and microscope being similar, the horizontal distance of any object could be obtained by direct telescopic observation upon a graduated staff, the distance being read off through the microscope; such is the principle of Eckhold's Omnimeter. In the tacheometer a frame is used carrying a diaphragm with five parallel lines, the middle one of which corresponds to the ordinary horizontal wire of the level, the two remaining pairs being placed symmetrically on each side of the middle one. By use of the analatic lens, the reading of the distance on a graduated staff intercepted between either the outer or inner pair of lines, when multiplied by a corresponding constant, gives the horizontal distance of the vertical staff from the centre of the observer's instrument. When taking

observations to a point placed at a higher level than that of the observer, it is necessary to multiply the "generating number," that is, the difference of the staff-readings multiplied by the constant, by the cosine of the angle of elevation. The author said that from his experience of trigonometrical work of all kinds, as well as of tacheometry, he was of opinion that for most longitudinal and cross-section work, more especially for marine work, the tacheometer was much to be preferred to the "level, theodolite, and chain," both as regards expedition and economy of chain-men, and in some cases of an assistant, where, for instance, two theodolites are being used to intersect the position of an object.

Mr. Thomas Morgans, in inviting discussion on the questions raised, complimented the author both upon his previous and his present paper. The latter one was of a rather technical character, but it was evident that the author was *au fait* with the subject with which he was dealing. The Chairman, who spoke at considerable length, was followed in the discussion by Messrs. Pearson, Stagg, Watts, Statesbury, Thompson, and A. P. I. Cotterell. The author, in replying at length to the various questions, remarked among other things that he had the honour of knowing Mr. James Simms, and had the pleasure of going over his works and of inspecting the whole course of manufacture of the fine instruments which, thanks to the courtesy of Messrs. Troughton & Simms, as also of Messrs. Husbands, of Bristol, they then had the opportunity of inspecting. It might be a matter of gratification to them to know that though they saw so many things imported from Germany, Belgium, and other countries, English mathematical instruments still maintained their old supremacy, and it was a fact that the larger number of surveying instruments used by Continental engineers were

ordered from Messrs. Troughton & Simms and other well-known English makers. The author concluded by urging upon engineers the great advantages of the Everest (3-screw) method of mounting instruments, of the use of micrometer microscopes in the place of verniers, and of the shifting-plate in addition to the usual mount, by which the work of engineers was much expedited, especially in the case of setting out railway curves where the pegs are placed among the bottom ballast of the new line. The paper was illustrated by a good collection of surveying instruments, such as tacheometers and theodolites, in addition to the collection of snakes and other objects of natural history, of photographs and maps, and of samples of Malayan workmanship exhibited upon the former occasion. A hearty vote of thanks to the author closed the proceedings.

"A Few Notches on Old Trees."

By Dr. A. J. HARRISON, M.B. Lond.

I HAVE given this title to the remarks I have the honour of bringing before this Society this evening, and must ask the members to regard my "notches" as observations or notes; or, in other words, that, in looking and searching about amongst trees, where a remarkable specimen has been found, we have made a notch or incision upon it,—mental only, not with an axe,—as it were, to particularise it.

Every one, I am sure, must take an interest in old trees, of whatever kind and wherever placed; and it occurred to me some time ago that it might not be uninteresting to others to have brought before them in, I trust, a fairly concise form a few details about the giants and patriarchs of the old forest kingdom. A noble-looking tree must strike every beholder with awe and admiration—with awe at its gigantic proportions and age, and with admiration at its marvellous form and beauty; and to these feelings is added one of deep veneration when we reflect upon the age of some, of their associations with the past, and their connection with the present time.

It is scarcely probable there are any oak trees now living which were flourishing when Julius Cæsar and his Roman legions landed in Britain, but there are doubtless many yew trees; and if we go to foreign lands, the sequoias of America

and the baobabs of Africa must have been quite venerable in the times of these Romans, and would have looked down upon them indeed as very *novi homines* when compared with their hoary antiquity. There are several yew trees in this country estimated to be between two and three thousand years old, whilst the baobabs of Senegal are reputed to be five thousand years old.

The Maronites believe that some cedars near the village of Eden, in Lebanon, are the remains of the forest which furnished Solomon with timber for the Temple, more than three thousand years ago.

But, after all, who knows the oldest living tree or trees in the world? Almost every tree-growing country claims the honour of possessing the oldest or the biggest tree—or perhaps both qualities. Is the oldest tree a yew, a sequoia, a baobab, a banyan or bo-tree, or is it a eucalyptus?

We shall have something more to say about this, but I do not expect we shall settle the point.

The trees which always seem most closely associated with our own country are the oaks, and we will therefore make a "few notches" on them first.

They are those of which the British nation has always been most proud. They were, so to speak, the idols of the old Druids, and in days more recent and in the good old days of ships, the "wooden walls" of England and "oaks" were almost synonymous terms. For majestic beauty we may well wish they were so now! What grander sight was there than to see the old Channel fleet in full sail!

The oldest existing oak in Great Britain is considered to be the Cowthorpe or Colthorpe one, growing near Ribstone Hall (from whence the famous apple takes its name), in the West Riding of Yorkshire. It is not only a remnant of the forests of ancient Britain, but a monarch among the

kings of trees. Five times has York Minster—man's work—fallen in half the period of this tree's supposed existence! The circumference of its trunk close to the ground is 78 feet, and at three feet higher, 48 feet. Its trunk is now hollowed, and is capacious enough to contain seventy people (many being children amongst them). Its main lateral branches once reached one hundred yards from its trunk, and covered about half an acre of ground. A leading branch fell down during a very severe storm in 1718, and it weighed 5 tons 110 lbs.! A few years ago the vicar of St. James', Wetherby, and the churchwardens and school children, to the number of ninety-five, got inside the tree, and while the vicar raised the Union Jack, the children sang the "Old Hundredth" and the "National Anthem."

A lover of the gentle craft one day plying his tempting bait in the river close by, went, by way of a change, to eat his lunch under the shade of the old oak. Hearing strains of music proceeding from apparently the inside of the tree, he was surprised to find an Italian organ man within, grinding from his instrument that well-known tune, "Home, sweet home." Being accosted by the lover of the gentle craft, he delivered himself thus: "Me travelled in Germany, France, Italy, and Spain, likewise England, but never before saw anything before like this, so me thought me would like to play de olde tune in de olde tree." I am able to state that the tree is still in very fair vigour, as Dr. Gibson of Wetherby very kindly sent me six acorns gathered this year, and also took great pains to furnish me with the latest information and photos.

Other renowned trees to be "notched" are the "Greendale" Oak in Welbeck Park, one of the most famous residences of the Duke of Portland, and the "Major" Oak, on the other side of the road, in an adjoining property.

The "Greendale" is only a shadow of its ancient grandeur. In the year 1724 a roadway was cut through its venerable trunk higher than the entrance to Westminster Abbey, and capacious enough to allow a coach and six to be driven through it. Tradition says that the opening was made in consequence of a bet made by Henry, the first Duke of Portland. When the tree was in its prime, it is said that 225 head of cattle might stand within the shadow of its branches! The supposed age is 1,500 years.

Not far from it, and another relic of the great Sherwood Forest, is the "Major" oak.

The "Major" is reckoned to be about 1,000 years old. Its trunk is hollow to the height of 15 feet from the ground. The "Greendale" I stated to be nearer 1,500 years; or to put the statement in another form, viz., about the time (410 A.D.) when the Romans finally abandoned Britain, this tree had emerged from its acorn germ, and had put an appearance above ground.

In September last I was visiting at Warwick, and I took advantage of the opportunity to see what remains of a once very famous oak, known as the "Bull Oak," in Wedgenock Park,—formerly a deer park of the Earls of Warwick, and situated a few miles from the town. It must have been a fine and shapely monarch in its prime, for the remains of one side of a tree which had evidently been hollow for many years measures now nearly 4 yards in width, and is the supporter of two huge arms.

There are not, nor have there been for several years (I should think) any leaves, although there may possibly be some sap circulation in the roots and bark. A spectator standing a little distance away might think he saw verdure upon it, but the greenness is that of an ash tree, which springs almost, nay, may really do so, out of the oak roots;

so you see in this case the ash rose and not the Phœnix. This oak was well described in Strutt's *Sylva Britannica* in 1830, when it was then regarded as 1,000 years old.

Another noted tree is the "Newland Oak" at Newland House, near Monmouth. It measures at the ground level 45 ft. 6 in. in circumference, and at 5 ft. from ground, 43 ft. 6 in. It averages 43 ft. for about 12 feet of its height. The trunk is apparently solid, but it is really much hollowed, the hollow being filled with dead leaves (*Quercus pedunculatus*). There is a tradition that it was mentioned in, the Domesday Book, but there seems to be no authority for the statement. It is believed to have outlived the 1,200 years allotted in the following lines to the Patriarch Oak:—

> "Three hundred years the oak expends in growth,
> Three hundred years in majesty stands forth,
> Three hundred years declines and wastes away,
> Then dies and takes three hundred to decay."

One of the most vigorous aged trees in the country is perhaps, "the Wotton Oak," near Aylesbury. It measures 25 ft. in circumference a foot from the ground, and at the height of 12 ft. divides into four huge limbs, the largest having a circumference of 15 ft. The tree is 90 ft. high, and covers an area of more than 50 yards in diameter. His Grace the Duke of Buckingham possesses also another splendid tree at the Michenden House, Southgate, Middlesex, called the "Chandos Oak." This has a very large spread of branches.

At Fredville Park, Nonnington, Kent, are many beautiful oaks. Three have attained much celebrity, and are known by the names of "Majesty," "Stately," and "Beauty." They differ in individual character. "Majesty" is the largest, being more than 28 ft. in circumference at 8 ft. from the

ground. "Stately" is a tall, straight tree, 70 ft. high. "Beauty" is not quite so tall.

At Burley, in the New Forest, there is a very fine group of trees, twelve in number, and hence named "The Twelve Apostles." They are very picturesque and grandly placed, and one would regret the loss or destruction of one of them. "The value of timber," says Gilpin, in his *Forest Scenery*, "is its misfortune." Every graceless hand can fell a tree. But the hand that fells an oak can also plant an acorn; but, says Evelyn, "men seldom plant trees till they begin to be wise, *i.e.* till they grow old, and find by experience the prudence and necessity of it."

In several parts of the country are trees known as "Gospel Oaks." These either formed parish or county boundaries, hence sometimes they are named "Shire Oaks"; but the name "Gospel" implies more than this, it bears the trace of religion. When these trees were worshipped, or formed centres of worship:—

> "It seems idolatry with some excuse,
> When our forefather Druids, in their oaks,
> Imagined sanctity."

Then it used to be the custom, in beating the bounds of parishes, for the minister, accompanied by his churchwardens and parishioners, to stop at remarkable spots and trees, and recite passages from the Gospels, and implore blessings from the Almighty on the fruits of the earth, and for the preservation and rights of the properties of the parish.

Yews.—Gilpin says, "The yew is a pure native of Britain, and was formerly what the oak is now, the basis of our strength. Of it the old English yeoman made his long bow, which he vaunted no one but an Englishman could bend." It was ordered to be grown in the churchyards to secure its cultivation, and its locality, where it could be found when

wanted. Nor is it celebrated only for its toughness and elasticity, but also for its durability. The hardy veteran fears neither storms above nor damps below. It is a common saying amongst the inhabitants of the New Forest that a post of yew will outlast a post of iron.

There are many very fine yews scattered about in Great Britain, and several are said to have been in existence for from 2,000 to 3,000 years. One of the most celebrated, and probably the oldest, is at Fortingall, near Aberfeldy, Perthshire, Scotland. Pennant described it as having a trunk 56½ ft. in circumference, and which divided into two distinct parts, between which funeral processions used to pass on their way to the church. What remains of it is now most carefully preserved. I was very much disappointed not to see this tree when in the vicinity last year, but the weather was so persistently wet that the visit could not be accomplished. Dr. Haggart of Aberfeldy has very recently written me about it, and he says the yew is just the same as when first enclosed for its safety. Before that time curiosity hunters and others made sad havoc with it. "But the greatest destruction," he says, "done to the tree was in the beginning of the present century, by boys keeping up the old custom of burning Beltane fires against it, like our still surviving Hallow E'en bonfires." There were evidences of the charred condition of the trunk in the memory of people still living. This tree is stated to be between 2,500 and 2,600 years old, and I might here make a few remarks about the method of calculation adopted, as there are some very interesting facts connected with this yew; but I will refer to them later on.

At Fountains Abbey, near Ripon in Yorkshire, there are still some remains of the magnificent trees which tradition asserts gave a shelter to the monks, who originally built

the Abbey. This was about A.D. 1132, so that at that time the trees must have attained to considerable growth.

The story runs thus: "There stood a large elm in the middle of the vale in which the Abbey was to be erected, and to this elm straw and thatch were attached, and under this temporary house the monks lay, ate, and prayed; the bishop, for a time, supplying them with bread, and the rivulet (the Skell), to drink. Part of the day some spent in making wattles to erect a little oratory, whilst others cleared some ground to make a little garden. But it is supposed they soon changed the shelter of the elm for that of the seven yew trees, growing on the declivity of the hill on the south side of the Abbey." In 1757 Dr. Burton wrote this account, and at that time all the seven, except the largest, were then standing, which, he says, had been blown down a few years before. Since then others have disappeared, having succumbed to gales and time, and now there is but one tree left.

In the Visitors' Handbook, published by G. Parker in 1888, it is stated: "On the left, near the present boundary wall, there stands, in great decrepitude, a living antiquity, a very large yew tree, said to have been coeval with, if not actually one of, the group of traditional yew trees utilized for a dwelling by the monks, who first tenanted the valley. At about 6 feet from the ground this tree measures 9 yards in circumference. It has survived all the stirring scenes enacted around it during more than a thousand years."

Another historical yew is at Ankerwyke, near Staines. It is said that Henry VIII. occasionally met Anne Boleyn under its shade. The girth of this tree at 3 ft. from the ground is about 28 ft., and at 8 ft. high it is 32 ft. 5 in., this increased bulk being caused by the stem bulging out before five principal branches go off in lateral directions.

Not far away is Runnymede—and the poet says:—

"What scenes have past, since first this ancient yew
In all the strength of youthful beauty grew!
Here patriot barons might have musing stood,
And plann'd the Charter for their country's good;
And here, perhaps, from Runnymede retired,
The haughty John, with secret vengeance fired,
Might curse the day which saw his weakness yield
Extorted rights in yonder tented field.
Here, too, the tyrant Henry felt love's flame,
And, sighing, breathed his Anne Boleyn's name:
Beneath the shelter of this yew tree's shade
The royal lover woo'd the ill-starr'd maid."

Another yew tree I should like to mention is at Aldworth, near Reading. The trunk, in the thickest part, measures 9 yards in circumference, and the out-spread of the boughs used to cover nearly half an acre. One long bough used to pass over the church wall into the Vicar's garden, and the boys of the village used to slide along it, drop off into the garden, and steal the apples.

About midway between Matlock and Chatsworth, at Darley, in Derbyshire, stands a venerable yew, stated to have existed for at least 600 years, and to be the oldest and finest in the county of Derby. It is thus noticed in Gisborne's *Reflections*:—

"Nor shall thy reverend yew, the tree who holds
His sceptre verdant through the changeful year,
Unnoticed stand. He has beheld . . . .
Thousands entomb'd within his shadow; heard,
For ages past, the sobs, the far-fetch'd groans
Of parting anguish ere the grave was closed,
And drank the mourners' tears!"

It measures round the trunk 33 ft. The tree is evidently now decaying. At the early part of this century boys used to get into the branches from the top of the wall, and com-

pletely cross the churchyard on to the roof of the church, on the opposite side, without descending to the ground.

Elms.—I have not much to say about these trees. They are very graceful, and are amongst the tallest of our English trees—about 100 ft. being the highest.

On a gentle eminence in the pleasure grounds of Chipstead Place, Kent, is an elm 60 ft. high, 20 ft. in circumference at its root, and 15 ft. 8 in. at $3\frac{1}{2}$ ft. from the ground.

There used to be a noted elm at the village of Crawley, on the high road from London to Brighton, the trunk of which, near the ground, measured 61 ft.

The "Tubney" or "Tyfield Elm," in Oxfordshire, has much local and some poetic fame.

Majestic as they are in appearance, and the first large trees to express the delight of spring by putting out their leaves, they do not rank among the "patriarchs of the forest." So far as I can make out, it seems very questionable whether any elm exceeds 300 years in age.

Beeches.—There was, in the early part of this century, a tree in Windsor Park, near Sunning Hill, known as the "Great Beech"; but I have not been able to ascertain its present existence. But at Stoke Pogis, in Buckinghamshire, there are the famous Burnham Beeches, two of which, the "Monarch of the Glen," which measures 27 ft. at the ground, and the "Hollow Beech," must have been grand trees in their prime. It was beneath the shade, or in the vicinity of these trees, that Gray, "the youth to fortune and to fame unknown," wrote his poetic musings, and thus describes himself:—

> "There, at the foot of yonder nodding beech,
> That wreaths its old fantastic roots so high,
> His listless length at noontide would he stretch,
> And pore upon the brook that babbles by."

The most magnificent beech tree perhaps on record is at Knoll Park, in Kent. Its height is 105 ft., and at 3 ft. from the ground its trunk is 24 ft. in circumference. It is curious that young beech trees retain their leaves all winter until 20–25 years old.

Chestnuts.—It is said the largest known in the world is at Mount Etna, in Sicily. At first glance it looks as though five large trees grew together, but closer observation shows that these are branches which spring from one solid stem, which measures 204 ft. round. It contains wood enough to build a palace with.

Within a few miles of Bristol, there still lives at Tortworth, the residence of Earl Ducie, one of the very finest old trees in the kingdom. In the reign of Stephen, who ascended the throne in 1135, it was deemed so remarkable for its size that, as appears upon record, it was well known as a signal boundary to the Manor of Tortworth, in Gloucestershire. It seems very probable that this tree is 1,000 years old at least. It is still in very fair vigour, as I can personally testify, and this year produced a large crop of nuts, the Spanish, the *Castanea vesca*. It measures nearly 50 ft. in circumference, the body is short—only about 10 ft. in height—and it then divides into three huge limbs, one of which measures nearly 30 ft. in girth. Many of the ancient houses in London were built of this wood; so is the roof of Westminster Hall. The hall was erected by William Rufus in 1099, and, I believe, is quite sound to this day.

This wood was used very largely in the enlargement of an hotel at Lynton, a few years ago—the Royal Castle Hotel (Baker's). The trees grew on the grounds of the place.

Willows.—There is a very fine one, the "Abbot," at Bury St. Edmunds. It measures about 75 ft. in height, and

has a circumference of 19 ft.—the two principal limbs 15 ft. and 12 ft. in circumference. A similar species of willow, viz., the *Salix alba*, grows at Haverholm Park, in Lincolnshire. It was thus described in the *Gardener's Chronicle* for Sept. 23rd last ('93): "At 1 ft. from ground, 27 ft. 4 in. in circumference; at 4 ft. from ground, 20 ft. 5 in. in circumference; at 7 ft. from the ground, 28 ft., owing to protuberances at base of the limbs. At 8 ft. from ground the tree breaks into eight large limbs, each equal to an ordinary-sized tree. It is 40 ft. high, and spread of branches 40 ft. on one side, and 28 on the other. It is perfectly sound in bole and limb. Supposed age, 1,000 years. It stands on a slight elevation, very like the bank of a river, probably the ancient bed of the Slea. A gooseberry bush grows from a hollow between two branches, and a thorn tree lower down."

Ash.—Apparently the largest stands in Woburn Park, the seat of the Duke of Bedford, in Bedfordshire. It is 90 ft. high, and of this the stem measures 28 ft. It is $23\frac{1}{2}$ ft. in circumference on the ground, 20 ft. at 1 foot, and 15 ft. 3 in. at 3 ft. from the ground.

There are several trees in various parts of the country which are higher, but none that contain such a bulk of timber. The extreme age of the ash does not seem to exceed 300 years.

The age of the lime is much greater. Authorities state that it may live for more than 1,000 years, viz., 1076 and 1147. We have no lime in this country approaching anything like this age. The largest is probably the one at Moor Park, in Hertfordshire. It is about 100 ft. in height, and has a circumference of 24 ft. at the ground, and throws out 19 large branches of 8 ft. each in girth, to the distance of from 70–80 ft.

At Troas, in the Grisons, there existed at the beginning of

this century a tree which was celebrated in the year 1424, and which, when last measured, was 51 ft. in circumference.

We have, so far, spoken of trees belonging nearly all to our country, and we are proud of them, and justly. We have called many of them "Patriarchs of the Forest," and they are so; but there are giant patriarchs which we have not considered, and for these we must go to Africa, America, and our Australian colonies, and Japan.

On the way we may allude to a celebrated "Soma Cypress" (so named) in Lombardy. It is said to be the oldest living tree in the world, but, as I stated earlier, tradition asserts this of so many trees. This cypress is said to have been a tree in 40 B.C. It is 120 ft. high, and its stem is 23 ft. round. Francis I. drove his sword into it, in despair, after the battle of Pavia, and Napoleon deflected the continuation of his road over the Simplon so as not to injure the tree.

Then the Japanese assert their title to the oldest tree of which the date can be authenticated. The "Nippon Dai Matsu," or Giant Pine of Japan, grows on the western shores of Lake Briva, at the foot of Mount Hizesan, three miles from Otsu. The tree is referred to in the archives of the famous monastery of Müdera, more than 800 years ago, and the priests assert that it was planted in A.D. 675. It is included in the "Omi Itak Kei" or Eight Beauties of Japan, and is yearly visited by thousands of pilgrims, who hope, by walking round the tree 105 times, to make sure of living another year. Formerly four houses were built in its branches, but two were blown down by the typhoon of 1870. The others are much patronized by dinner parties on summer evenings, and in wet weather the drops of rain falling from the tree have a very soothing effect. The diameter of the trunk 2 ft. from the ground is 15 ft. 9 in.; height

84 ft.; and its width over all is 242 ft. It has a spiral staircase leading up into the tree, and it is supported by no less than 326 props.

Then again the oldest trees are said to be baobab trees (*Adansonia digitata*) of Senegal, and the banyan or *Ficus Indica*. One of these latter grows on an island in the river Nerbudda, and is believed to have been flourishing in the time of Alexander the Great (B.C. 356), and which then, according to the historian Nearchus, was capable of overshadowing 10,000 men. Parts of it have been carried away by floods, but it can now shade 7,000 men, and its circumference, measuring its principal trunk only, is 2,000 ft. The chief trunks of this tree greatly exceed our English oaks in thickness, and are above 300 in number. The smaller stems are more than 3,000 in number. (Show Drawing.) The banyan sends down a large number of stems from the branches to the ground, and these then form aërial or adventitious roots—several thousands of them in old trees—and in this way, by extension upon extension, one tree covers a very large extent of ground. The banyan is held in special reverence by the Brahmins, as is its congener, the Sacred Fig (*Ficus religiosa*), also called peepal and bo-tree by the Buddhists, so that it is said the sites of temples can be readily distinguished as Brahmin or Buddhist by the presence of one or other tree.

The bo-tree of the sacred but ruined city of Anuradhapura, 80 miles north of Kandy, is (it is said) the oldest tree in the world. It is stated to have been planted in 288 B.C. as a branch of the tree under which Gautama sat when he became Buddha (Sir James Emerson Tennent believed that in 1859 the tree was really of the wonderful age of 2,147 years). The baobab or *Adansonia* is believed to be the largest tree, as regards trunk, in the world, the stem being

from 20 to 30 ft. in diameter, and some much more. The fruit is called monkey-bread, and is of the size of a citron.

In Calaveras County, North America, and in the Yosemite Valley, near San Francisco, are certainly (and this without query) some of the most remarkable trees in the world, the sequoia trees. The *S. gigantea*, or Wellingtonias as we term them often in this country, belong to the natural order Coniferæ or pines. They are appropriately termed "Mammoth Trees." They grow in sheltered valleys at high elevations, viz., 4,000–7,000 ft. above the sea level. The Mammoth grove of Calaveras consists of from 90–100 trees of gigantic proportions, varying in height from 300–400 ft. One of the most notable is named "The Mother of the Forest." It rises to the height of 327 ft., but is dead and barkless. Its girth near the base is 75 ft. I dare say some of you may recollect seeing the skeleton of an enormous tree in the Crystal Palace at Sydenham, until the portion of the Palace and this tree were destroyed by fire in 1866. This skeleton was the bark of this very tree, stripped off for 110 feet of its height. The bark itself measured in thickness about 18 inches. Another tree, "The Father of the Forest," is a huge prostrate trunk, which measures in girth 110 ft. In falling the trunk broke off at the height of 300 ft., and at that point the girth is 40 ft., and taking the average taper of the surrounding trees, this dead giant may reasonably be computed to have exceeded 400 ft. in length, or better, in height. Inside the fallen branch there is a tunnel 35 ft. long, and from 8 to 10 ft. high. The "Pioneer's Cabin," a cavity in the trunk of another giant, is large enough to accommodate a numerous party at dinner.

The "Three Graces" grow within a few feet of each other, and are famous for their symmetry and beauty. They are of about an equal height, 265 ft. In San Fran-

cisco a spacious room has been formed from the bark of one of these trees (the sequoias, not the Graces). The bark was stripped off to the height of 21 ft. and then placed together. The room is carpeted, contains a piano, and will seat 40 people. On one occasion 140 children were crowded into it.

In the *Times* of September 19th, 1891, there was a statement that a red-wood tree (*Sequoia sempervirens*) was going to be made into two railway carriages, and sent to the Chicago Exhibition. One carriage was to contain a dining-room, a buffet, a bath-room, a barber's shop, and a kitchen; and the other was to be a sleeping car and an observation-room.

Gigantic as these sequoia trees unquestionably are, it seems highly probable that some of the eucalypti or kirri trees of Western Australia are even more mammoth-like. Some of them attain a height of probably not less than 500 feet. One of them—hollowed—allowed three men on horseback and a pack-horse to ride into it, and turn round, and come out again! Let me give you a comparison of what this height means:—

To the top of the cross on St. Paul's in London is 404 feet.
„ „ Strasburg spire is ... 440 „
„ „ Pyramid of Cheops is ... 480 „

Some of these trees would top them all!

A few remarks about the ages of trees and the methods of computation, and I have done my pleasurable task, and distressed, I fear, your patience.

During the remarks I have made, I am quite sure I have served rather to muddle than clear up the question of what tree or trees are the oldest in the world, so many authorities have claimed the honour for their favourites. One thing is very clear; viz., that all Anno Domini trees are

quite out of court if B.C. trees are in existence. That if an existing banyan tree (to which I have alluded) sheltered the hosts of Alexander, say 300 B.C., it must have been a very old tree then, and 3,000 years could not be an over-estimate of its age. Decandolle, judging from the size and growth of the baobab trees (*Adansonias*), considered that some of these ought to be computed to be 5,000 years old!

Then, I think, we must admit there are yews which are between 2,000 and 3,000 years old. How are these estimates made?

As a rule a forest tree makes a woody circle every year, and therefore, if you count the concentric rings in any through section of a tree or branch, you ought to be able to calculate their respective ages, and you could tell when the branch was given off from the parent stem. In some years, however, and with some trees certainly, instead of one ring we may have two or three formed, owing most likely to unusual alternations of heat and cold. This condition would bring about over-computation. Against this may be set the fact that in some years, owing to the peculiarities of the seasons, or damage done by very severe frosts, no ring may be formed in that year.

With regard to sequoias and red-woods, we know from experiments that they may form several concentric woody circles in some years. Then, certain marks have been found in trees after they have been cut down, which have established the periods of growth since. Thus, in felling and sawing up some of the old trees in Sherwood Forest, letters were found within the wood of several—depressed letters in one circle, and then the next year filled up the depressions corresponding to the incisions with new woody fibre. Thus in one tree was found a crown carved with "W. M.," for William and Mary. In another, "I," with a crown, peculiar

to King John's time. The tree containing "W. M." was cut down in 1785, or nearly one hundred years after their accession; the letters were nine inches within the tree, and three feet three inches from the centre. The letter "I" and crown were eighteen inches within the surface, and about a foot from the centre.

When describing the Fortingall yew, I said I would refer to it again in relationship to the ages of trees.

Dr. Haggart, of Aberfeldy, who has given me most kind information on the subject, tells me that the late Dr. Guthrie, of Free Church renown, believed in the assigned age of the tree, and in his characteristic way described it as being a "sapling when David was a boy." Then the late Professor Christison, of Edinburgh, who must certainly be regarded as a very good authority, spent some time near Fortingall, and took much interest in the tree and pains in making sections of portions of the trunk and branches, in counting their concentric rings, and in making careful measurements of the various parts of the tree.

Counting the rings of a tree like a yew is not a very easy task. It is sharp work for eyes and fingers. A lens has to be used, and every now and then a needle has to be inserted in the wood to indicate a pause or resting-place. You then continue counting from the needle, and insert a second for a second break, and so on, like marking the score on a cribbage board. Christison came to the conclusion that the traditional age of the tree and the apparent scientific one corresponded very, very closely. Long, indeed, may it be before some of the trees we have "notched" this evening come to be placed in the examiners' hands—be he a Christison, a Decandolle, or a Balfour.

[The lecture was illustrated by photographs or drawings of most of the trees, but these we cannot, of course, give.—EDITOR.]

The Brown or Tawny Owl.

(*Syrinum Aluco.*)

By C. F. DRUITT.

TO any one who has had a fair opportunity of studying its habits, this bird is one of the most interesting on the British list. It is fairly common in England and Scotland, but in Ireland it is unknown. On account of its retired habits and sober plumage, it is not so often seen as heard. Its weird, nocturnal hoot must be familiar to almost all dwellers in the country. Unlike the barn owl, it does not haunt old buildings and towers, but prefers the solitude and dark recesses of the woods. I have heard it, though not very often, in the Leigh Woods, Clifton.

The bird is chiefly, though not entirely, nocturnal in its habits. I do not believe, however, that it often makes *voluntary* peregrinations by day, as it is then almost invariably mobbed by a concourse of insulting birds chiefly of the small varieties, which drive it from place to place, keeping up a noisy chattering all the while; nor do they leave it until at last the tormented owl thankfully reaches some secluded refuge such as that from which it was originally disturbed.

I remember on one occasion, whilst wandering in broad daylight through a wood near Dolgelly, hearing loud

screeching or screaming coming from the other end of the wood. On reaching the spot whence the noise proceeded, I witnessed a curious sight. There were half a dozen or more jays mobbing a poor tawny owl, who appeared so bewildered that she knew not where or how to make her escape. Doubtless the mischievous jays were answerable for the breach of peace. However, at that time I was anxious to obtain a specimen of *Syrinum Aluco*, and having my small collector's gun with me, this opportunity was one not to be missed. The owl was being driven from tree to tree, closely pursued by the screaming jays. I chose a likely-looking oak and waited close to its trunk, and in a few moments the same lively scene was being enacted right over my head. The report of the gun soon ended the disturbance, the owl being laid low and the jays rapidly dispersing in all directions.

On another occasion I was with a friend in a wood not many miles from Clifton, known by the suggestive name of "Goblin's Coombe." It was about mid-day, and whilst resting in the shade, our attention was caught by the prolonged grating note of a common wren. So continuously was this noise kept up that we knew something must be wrong. On nearing the spot we soon caught sight of the diminutive but much agitated bird. With ruffled plumage it was bustling about the mossy stones and low underwood, now perching on some eminence, bowing its body and jerking its tail, and now diving into the recesses of the bush, but uttering its harsh note with great vehemence all the while. The cause of this was not at first apparent; but on approaching nearer, to our astonishment a tawny owl fled from a tree hard by and soon vanished out of sight.

The disappearance of the owl evidently caused the wren great satisfaction, for it instantly ceased its noise, and

settled down again to its maternal duties with perfect equanimity. With regard to the plumage of this owl, little need be said here; its two descriptive titles, "brown" and "tawny," convey a good idea of its general colouring.

It is interesting to note, however, that there appear to be two phases of this species, a red and a grey, sometimes one shade predominating and sometimes the other. The plumage is very soft and downy, the wing feathers being covered with a delicate plush, whilst the free border of the outer primary is distinctly ciliated.

These provisions of nature enable the owl to fly, or rather float, through the air without making any flapping noise with its wings—a proceeding which would soon warn its sharp-eared quarry of the approach of an enemy. What creatures constitute the food of the tawny owl? This gives rise to the vexed question as to whether this bird is destructive to game or not.

One writer says: "The tawny owl does not prey exclusively on mice and small birds, but makes great havoc amongst game." Whereas other competent observers have declared that it is quite innocent of the charges brought against it in this respect. The latter statement is based on a very remarkable feature of the owl's economy.

Unlike most birds of prey, owls do not waste time in picking the flesh off the bones of their victims; but they are either swallowed whole immediately on being captured, or if too large they are just torn into two or three pieces. Hence, bones, hair, and feathers are swallowed as well as flesh and blood.

These indigestible parts are then separated from the remainder by the process of digestion, and are thrown up in the form of "pellets."

An examination of these pellets, therefore, clearly proves

the nature of the bird's food. Now Dr. Altum took great pains in examining 210 pellets of the tawny owl, and found them to contain the remains of the following:—

"1 stoat, 6 rats, 371 mice, 48 moles, 8 small birds, besides many beetles and cockchafers."

Such observations as these are exceedingly useful and instructive, for they not only show how improbable it is that the bird interferes with game at all, but also how great a service the bird renders to man in keeping down the numbers of destructive vermin which would otherwise increase so rapidly as to give rise to disastrous results.

I have a few brown owls' pellets with me that were taken from a deep hole in an old tree which must have been frequented by these birds for some years.

It will be seen that there are no bones amongst them of any larger game than mice and sparrows.

Here is also a specimen of a common shrew which I found whole in the stomach of an owl sent to me a few months ago.

The shrew must have been swallowed only a very short time before the bird was shot.

Of course the easiest way to swallow a mouse would be head foremost, and I proved that the owl had done so, in this case at any rate, by the following incident.

Before opening the stomach to examine its contents, I severed its connection with the gullet by means of a pair of scissors. When the shrew was discovered, I noticed that his tail was represented by a mere stump. Closer inspection showed signs of very recent amputation, and sure enough in the lower end of the gullet I found the missing link, which being the extremity of the bolus had never gained entrance to the stomach at all.

The tawny owl will occasionally vary his ordinary fare of

mice and small birds to that of fish. I will ask permission to quote a most interesting account by an eye-witness of this fact. It is from the book entitled *On Surrey Hills*, "By a Son of the Marshes." "No sound is to be heard but the ripple of the water over the broad shallow which reflects the light of the moon. The dead limbs of a beech tree project over the water. Three noiseless forms pass overhead and settle on the white limbs of the old beech. One adult and two young (brown owls) are there. The two young birds are on one limb, where they chatter together in owl fashion; the old owl perches on a limb directly over the shallowest part of the river. Fish are working about, roach probably, for their sides flash silver, as they scuttle over the pebbles of the ford. I chance to tread on a little twig—it snaps; there is only the slightest sound, but they hear it. Instantly their heads and bodies are erect like those of soldiers, looking half their usual size, for when alarmed their feathers are drawn close to the body. Finding that nothing ensues after the snapping of the twig, they settle down as before, the young ones softly whining to each other. The old bird now begins to sway to and fro, the head moving round first one way and then another. There is a flash of fish on the pebbles; down drops the owl and fixes one. The water flies in showers of sparkling drops as the fish make for deeper water, whilst the one captured kicks vigorously.

"No chance of escape; the owl grasps the fish with one foot and hops with the other; then up he goes to the young ones. The prize is a good-sized fish, apparently a half-pounder. A great commotion follows; there is much flapping of wings and whining on the part of the young owls as they all shoot off to their dining-room at the foot of the Whites."

Thomas Edward, the Scotch naturalist, describes how, when listening one night to a frog-concert in the middle of Backlaw Wood, the orchestra, when at its full height, became suddenly hushed by the presence of a tawny owl who alighted on the top of a low dyke. There was perfect silence for half an hour, when the owl made a sudden dash amongst the rushes and flew off with a *frog* dangling in its claws.

The call-note of this bird is well described by Shakespeare in the words, "tu-whit, tu-whoo!" followed, after sometimes a long pause, by a tremulous repetition of the last syllable, "whoo-who-wo-o-o-o."

The note of the young bird may be represented by "kee-wick." Another note, "chut, chut," is mentioned by Mr. Herbert Payne as an alarm note in his most interesting account of a free-flying tawny owl which he tamed when young, it becoming much attached to him.

Something must now be said with regard to the nesting habits of the brown owl. The bird cannot be said to build a nest, properly so called, but it commonly selects a large cavity in an old tree, being partial to such as have ivy clustering around the opening.

In such a place as this may be found a small collection of sticks, pellets, and feathers of devoured birds.

A nest which I found in this neighbourhood was in a hollow, stunted oak, having a large aperture above open to the sky, and a smaller one at the side almost within reach from the ground.

This nest was found on March 14th, 1890, and then had one egg in it. By the 19th there were three eggs. Two of these were taken, one by myself and another by a friend who was with me. We were very much afraid that the birds might desert, but still could not miss the opportunity of

adding this egg to our collections. I am glad to say, however, Mrs. Tawny showed no intention of forsaking, but faithfully continued to sit on the remaining egg, and did not appear to resent being frequently visited. On April 13th, just one month from the date on which the first egg was laid, an odd-shaped fluffy ball, representing a tawny owlet, was revealed to the light of the sun, or perhaps more accurately speaking to that of the moon, for on no occasion when visited by *day* was the young owl left to itself, but one or other of the old birds was always sheltering it beneath its wings. I never once saw, however, both adult birds on guard at the same time. A very extraordinary, but indescribable, creature was this young tawny; nevertheless, under the constant attention of its watchful parents it soon grew into a recognisable object. Doubtless, being the only mouth to be fed, it came in for an unusually large share.

On May 17th, when five weeks old, the young bird left its secluded nest. It could not, of course, fly well at first, and even a day or two later it allowed itself to be easily caught with the hand.

It was at this time one of the most beautiful living objects I ever saw. Its fresh young plumage of all shades of gold, yellow, and brown, and its grave, stately, but notwithstanding somewhat pugnacious, manner, made it exceedingly fascinating. I much wished to keep it as a pet, but knowing the care and time it would require, I preferred to leave it to enjoy the solitude of its native wood.

Although hollow trees seem the favourite nesting haunt of the brown owl, it has been known to resort to rabbit burrows. Deserted nests of crows and magpies are also sometimes selected; I have personally known of two instances in which an old magpie's nest was chosen.

Yarrell mentions a case in which a pair of brown owls brought up their brood in a tree near a magpies' nest, with which birds they had frequent combats; at last the remains of the young magpies were found under the owls' tree, and in one instance the head and feathers of one of the old magpies.

The tawny owl, although not maliciously disposed, does sometimes resent an approach to its nest, and has been known to inflict serious injuries on human beings when it has young.

Some friends of mine knew of a boy in Devonshire who had an eye torn out by a brown owl whilst the lad was attempting to rob its nest.

I will relate an instance of an attack made by this bird which came under my personal observation, although I am glad to say in this case no grave result followed. It was on the evening of May 5th, 1891. Whilst looking out of one of the windows of a house in Wiltshire, where I was staying, I noticed two brown owls moving about amongst the branches of a large elm some little distance off. Presently one of the birds seemed to flutter in a somewhat helpless manner to the ground. I waited to see what would happen, as a man was crossing the field and would pass near the foot of the tree. The bird on the ground, instead of making any attempt to fly off, remained so still that it was not noticed. I left the window to make my way to the spot, but before I could reach it, I met another man coming towards the house with the owl, young tawny, under one arm, whilst with the other he held his handkerchief to his neck, which was bleeding pretty freely. He told me that whilst stooping down to pick up the a young owl, the old bird suddenly dashed at him, and struck him on the neck with one of her talons.

Wishing to see if the bird would repeat this pugnacious, albeit courageous, performance, I carried the young owl back and placed it at the foot of the tree, having previously taken the precaution of putting up the collar of my coat. There was the old bird perched in a stately manner high over my head, constantly snapping her bill, which seemed to me a sign of rage. Keeping my eye fixed upon the adult bird, I bent over the young one and made it fight with my hand. Suddenly, before I was aware that the old bird had left her perch, I felt a smart blow in the back, which on a less unfavourable spot would certainly have left its marks. The shock made me start, of course, and this had the effect of driving the owl back to the elm tree, where she continued the snapping noise previously mentioned. I did not wait for the second round, nor did I venture to examine the hollow overhead, which doubtless contained three more owlets; but, thinking discretion the better part of valour, I retired, carrying this young one away with me as a trophy.

The Nuthatch.

(*Sitta Europæa.*)

By C. F. DRUITT.

THIS small denizen of woods, gardens, and orchards, is a familiar object to most dwellers in the country. In some respects it resembles a woodpecker, for which it is often mistaken by those who see it for the first time. It is, however, a bird of essentially different character, habit, and structure, and has the advantage of being much more common, particularly in the south-east and central counties of England. It is not known to have occurred in Ireland.

The nuthatch usually first reveals its presence by its shrill, bubbling and joyous twitter, which is constantly repeated as it traverses by a series of quick jerks the rough bark of some neighbouring tree.

This note, which may be represented as "whit, whit," having once been heard and appreciated cannot possibly be afterwards mistaken for that of any other bird. It is a sturdy, well-built, muscular little fellow, easily attracting the attention of the ordinary observer, and will, moreover, generally admit of pretty close inspection. Its plumage is of a bluish-grey colour, covering the back, neck, and top of the head. The breast and under plumage are of a dull orange red, the cheeks and throat white, with a streak of black running through the eye. The tail is short, and is *not* used to

support the spine in climbing, as is the case with the woodpecker. The feet are of the passerine type, in contradistinction to the yoke-toed modification. That part of the nuthatch which most closely resembles the corresponding part of the woodpecker is the bill. It is a straight, stout, sharp-pointed wedge, and well does its owner know how to make good use of it in a variety of ways. First, the bird depends entirely on its bill for procuring its food, as it is *not* gifted with the marvellous, extensile tongue of the woodpecker family. If the movements of the bird are watched as it rambles, regardless of the laws of gravity, over every part of the tree, it is seen to frequently stop and closely examine the cracks and crevices of the bark, from which it delicately removes some of the smallest forms of insect life. But should the bird, however, detect some grub lurking deeply beneath the surface, he does not hesitate to use stronger measures, and soon hacks away the bark and decaying wood until the coveted morsel is obtained.

But there is even a still rougher use to which this bill is subjected, and from which particular habit the bird derives its name. As soon as ever the nuts are ripening in the garden, the nuthatch becomes aware of the fact, and may be seen searching for, and nipping off, the most advanced filberts. It is evident that the bird cannot extract the kernel on the spot. What therefore does he do? Off he flies, carrying the nut in his bill, to some favourite tree whose bark is full of cracks and holes. Into one of these crannies he wedges the nut, and taking his stand above it, with his head downwards, in order to obtain the greatest power, he continues to hammer away at it until a piece of the shell cracks off and the kernel is exposed. If the nut becomes dislodged, the bird replaces it, and it has been seen to catch the nut in its bill before it has had time to reach

the ground. Each stroke is delivered with the full force of the body, the head and neck being kept rigid, the movement being in the hip joint. As if to gain impetus, each blow is accompanied by a simultaneous flap of its closed wings against its sides. The energy and perseverance of the bird when thus engaged render this one of the prettiest sights imaginable, and one which can only be fully appreciated by those who have actually watched it at work.

The second syllable of the word "nuthatch" is derived from the French "hacher" to chop, from which our word "hatchet" is derived. In the country the bird is sometimes called the Nutjobber.

Its *nesting habits* are particularly interesting, as they are entirely different from those of any other British bird. It usually selects a hole in a tree just large enough to admit of its passage through. I have twice seen the deserted hole of a green woodpecker used as a nesting site by the nuthatch, but in both these cases, as indeed whenever the entrance hole is much larger than the circumference of its own body, the nuthatch displays considerable engineering skill in reducing its diameter. This operation is carried on entirely by means of its bill, which is now used as a plasterer's trowel. Flying off to some spot close to water the bird gathers up a small mass of soft mud or clay, and returning to its future nesting hole, spreads the mud around a part of the entrance, and leaves it to dry hard. This process is continued until a complete lining has been constructed within the original hole, having only a small circular orifice in its centre. I have met with two instances in which the nuthatch selected a hole in a wall instead of in a tree. One of these was in a garden wall which also formed the back of an outhouse. The wall was built of bricks facing endways, with here and there a space where a

brick had been left out. In one of these gaps, measuring about four inches square, I found a complete lining of mud such as I have described. I tried to cut it out entire, but as it was some months since it had been placed there, the mass crumbled to pieces. After this was removed, I got my hand well into the hollow space behind, and turned out all the material I could find. This hole had been used by the birds, as I afterwards learnt from the gardener, for seven or eight years consecutively, which accounted for the large amount of material that had there accumulated. Very few, if any, leaves were used, but a great quantity of the thin scales found on the bark of fir trees, placed together without any particular order so far as one could see. I found, moreover, two or three eggs which had been buried for some time beneath the pile. There were also in the hole a number of small fragments of wood and bark of various kinds, to which the birds seem to have taken a fancy, as some of them show traces of ornamentation by the birds' bills. Being anxious to obtain a perfect specimen of the plastering work of the nuthatch, I devised the following experiment: before leaving the hole I inserted into it a thin piece of wood curled up into a circular shape, and gave instructions that if the birds placed a lining of mud within it the following year, the wood was to be taken out entire and reserved for me. I was much gratified to find that in the following spring the nuthatches did just what I desired; and moreover, did not forsake their nest, but built up another lining of mud within two days of the removal of their first earthwork. An examination of some fragments of the mud brought together by the nuthatch seems to indicate that the bird knows the value of hair or some other fibrous material in causing the mud to bind firmly *en masse*. There is a nest of the nuthatch in the South Kensington Museum which was

built in a most singular situation, namely, in a hole in a hay-stack. The amount of mud which the birds brought together in this case is something astounding—it weighed no less than eleven pounds.

In a most interesting account of a tame nuthatch kept by Mrs. Brightwen, a fact is mentioned which suggests that the bird may lay up a store of food for a winter's day. She says:—

"Zoe regularly honeycombed the little tree-stem with her incessant hammering, and in the numerous holes thus made she kept her store of food. No sooner was her tin filled with small pieces of raw meat than she began stowing them all away for future use. She seemed to exercise a good deal of thought about the matter: a morsel would be put in and out of a hole half a dozen times before it was considered settled and suitable, and then it had to be well rammed in and fixed, and off went the busy little creature to fetch another piece, and and so on till all was disposed of, and the tin left empty."

I have never been able to gather any further information on this question although it seems likely that a store is made.

In order to show that this bird is by no means so uncommon as some people suppose, I may mention that I saw half a dozen of them this very afternoon in Ashton Park. They all alighted together on the trunk of a large elm and were soon busy in search of food, twittering loudly all the time. After watching them for some five minutes, I noticed that they seemed to suddenly disappear one by one, and soon there were none to be seen, and their note had ceased. As I was quite sure they had not flown off, I came to the conclusion that they had retired to roost in some hole out of sight. The explanation was rendered probable by the time of day, which was about 5 p.m.

The Rhætic Rocks of Pylle Hill, Bristol;

WITH SOME GENERAL CONSIDERATIONS AS TO THE (UPPER AND LOWER) LIMITS OF THE RHÆTIC FORMATION IN ENGLAND.

By E. WILSON, F.G.S.

(*Curator of the Bristol Museum.*)

IN a paper read before the Geological Society of London in the year 1891,* I described an excellent and typical section of the Rhætic rocks, which had recently been opened up by the construction of the Bristol Relief Railway, at Pylle Hill, Totterdown, on the south side of the city of Bristol. Following the reading of this paper a discussion arose, in which several geologists who have considerable acquaintance with the Rhætic rocks of this country took part, namely,—Mr. R. Etheridge, senr., Mr. Horace B. Woodward, Professor T. Rupert Jones, and the Rev. H. H. Winwood. Although I had no reason to complain of the way in which my paper was received on this occasion, one or two exceptions were taken to certain of my views, to which, as I was not present, I had no opportunity of replying; whilst upon one point my conclusions were, unintentionally no doubt, distinctly mis-stated.

* *Quart. Journ. Geol. Soc.*, vol. xlvii. p. 545.

It has been suggested to me that an account of this local section, which I may mention was visited by a party of the Bristol Naturalists' Society in the summer of 1891, under my guidance, might be of some interest to the members of your Society, whilst it would at the same time give me an opportunity of meeting the objections of my critics to which I have referred.

You doubtless know that the Rhætic rocks—that interesting connecting series between the Trias and the Lias—which are so well developed in the Rhætian Alps of Lombardy, the Grisons and the Tyrol, in this country form a thin, although a remarkably persistent, rock-band, which may be followed diagonally across England from the Channel, near Lyme Regis, to Redcar on the North Yorkshire coast. Owing to the fact that the Rhætic rocks in England are not only a thin series, but are also, in the main, of a softish nature, and yield, as a rule, no minerals of economic value, they are not often exposed either in inland scarps or in quarries; and we have therefore in a general way, to trust to railway-cuttings, road-cuttings, wells or other similar artificial excavations for giving us opportunities for their examination. In the West of England, however, this is not altogether the case, for in this part of the country the Severn has, at several points along its course, carved out splendid sections in these rocks, which not only admirably display their extent and character, but also clearly exhibit their relations with the underlying Trias and the succeeding Liassic rocks. Such are the classical sections exhibited in the cliffs of Westbury-on-Severn, Aust Cliff, Penarth, and Watchet, all of which have at different times received a more or less full and adequate description from one author or another. Inland, however, for the reasons I have already explained, exposures of these rocks are somewhat rare. Thus, when any artificial opening

is made in them, students who give their attention to this department of British geology are glad to avail themselves of the opportunity thus afforded of studying these interesting rocks whilst the opportunity lasts.

The section I am about to describe is the one on the Bristol Relief Railway, which is seen on looking over the west side of the bridge over this railway on the Bath road, at Pylle Hill (Totterdown), Bristol. Although the general sequence of the beds may still be seen in the steeply-sloping bank on the south side of the line, the details are now obscured; the section, too, is now practically inaccessible to the geologist, and as time goes on it will become more and more defaced by the action of the weather. Almost in a line with this section, a little further west, on the main Bristol and Exeter Railway, there is another and a much older section, practically a counterpart of the one now under consideration, which was described by the late Charles Moore—but necessarily very briefly and inadequately—in an abstract of a paper read by him before the Geological Society in the year 1860.*

The railway-cutting in which the section I now describe is exposed runs east and west, or approximately along the strike of the beds—the dip being S.S.E., at an angle of 3° or 4°. In the line of section, therefore, the beds are nearly horizontal, but they have a very gentle synclinal arrangement.

The general succession of the beds at Pylle Hill is as follows:—

From the level of the line to a height of about forty feet above it come the variegated red and green marls of the Upper Keuper division of the Trias. These red and green

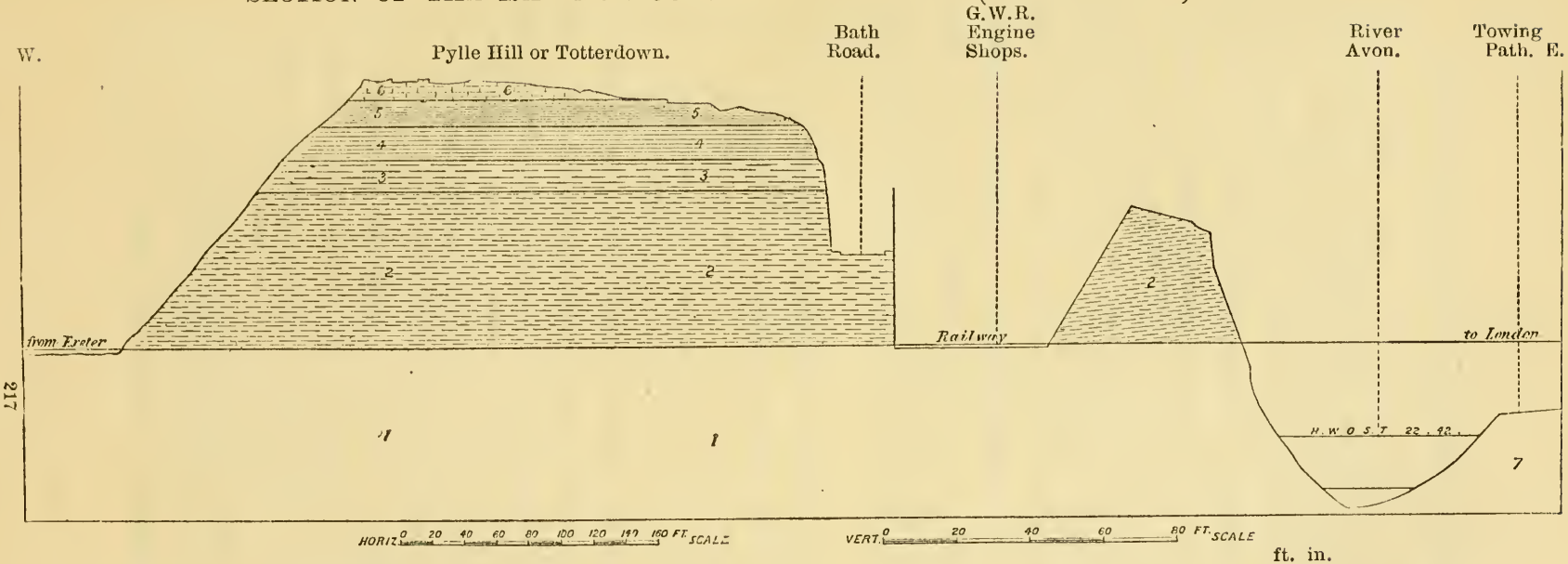
* On the so-called Wealden beds at Linksfield, and the Reptiliferous Sandstones of Elgin. *Quart. Journ. Geol. Soc.*, vol. xvi. p. 445.

marls are succeeded conformably, and indeed with an imperceptible gradation, by about nine feet of somewhat indistinctly bedded light greenish-grey marls—the "Tea-green Marls" of the Government Geological Survey. These latter beds have hitherto been included by the Survey authorities in the Rhætic series, and this arrangement, coupled with the inclusion also in that series of the true White Lias, has no doubt materially exaggerated the extent of the areas occupied by those rocks on the Survey maps. I shall presently give reasons for removing these "Tea-green Marls" from the Rhætics and classing them with the Keuper. Above the Grey or "Tea-Green Marls," then, come the Rhætic beds, which at Pylle Hill, as generally in this country, consist of two well-defined series, namely, black, thinly laminated "Paper Shales" or *Avicula contorta* beds below, and light grey limestones and shales—my "Upper Rhætic Series"*—above. Before concluding this paper I will give some account of these beds, and for further details regarding them would refer you to the accompanying section. (See page 229).

The Rhætic beds are succeeded by three or four feet of rubbly, cream-coloured limestone and shale, which from their peculiar light tint are generally distinguished by the term, "White Lias." The section is completed by nine or ten feet of the ordinary regularly bedded limestones and shales of the Lower Lias, containing fossils characteristic of the zone of *Ammonites planorbis*. (See Fig., p. 217.)

* It is to be understood that the division of the British Rhætics into an Upper and Lower Series here adopted, does not correspond with a similar division which has been made of the continental Rhætics, but is merely a convenient method of distinguishing the two very different portions of this series within the British area. Probably the whole of the Rhætic beds of Britain would belong to the Upper Rhætic Series of continental authors.

SECTION OF THE RHÆTIC ROCKS AT PYLLE HILL (TOTTERDOWN) BRISTOL.



217

		ft.	in.
7.	Alluvium		
6.	Lower Lias limestones and shales	11	2
5.	Upper Rhætic shales and limestones...	7	7
4.	Lower Rhætic, *Avicula contorta* shales	9	5
3.	Upper Keuper "Tea-green Marls"	9	0
2.	Upper Keuper red and green marls, above railway level	40	0
1.	,, ,, ,, below ,, ...		
		77	2

NOTE.—The vertical scale is exaggerated in the above section, being about twice the horizontal.

[*For the loan of the accompanying plate we are indebted to the Geological Society.*—ED.]

One of the first things that strikes us in this Pylle Hill section—and it is a matter to be taken into account when drawing any general deductions from same—is the very limited development of the Rhætic beds, the whole series, according to my estimate, measuring only 17 feet in thickness. This is not more than half the thickness these beds usually attain in the West of England. At Westbury-on-Severn, for instance, the Rhætic beds are 33 feet in thickness; at Aust Cliff, 34 feet; and at Penarth, 42 feet; whilst at St. Audrie's Slip, to the east of Watchet, and at Queen Camel, near Yeovil, they have been estimated at as much as 150 feet in thickness, although it is pretty certain that in both these latter cases more beds, both of those overlying and those underlying the true Rhætics, have been included in them than is right.

The next point to which I would direct your attention, and which the Pylle Hill section illustrates very clearly, is the sharp line of demarcation there is between the so-called "Tea-green Marls" of the Keuper and the overlying black "Paper Shales" or *Avicula contorta* beds of the Rhætics. In all the sections of the Rhætic rocks in this country which I know, with the possible exception of that at Watchet (and this would probably turn out the same if it were more accessible and could be examined at close quarters), the line of division between these two series is as sharply defined as in the present case, the lithological characters of the two series are totally different, and often there are signs of slight erosion of the "Tea-green Marls," which may contain in small fissures and inequalities in their upper surface material which has settled down into them from the overlying Paper Shales; whilst a hard conglomeratic "bone-bed," or at any rate a seam of pebbles, with coprolites and fish teeth, scales and bones, very generally occurs at the base of the overlying

Paper Shales. Such features as these, coupled with the fact that in crossing this line we pass upwards from a rock-series which is uniformly destitute of organic remains, and which merges into a great unfossiliferous series below, into a rock-series which contains numerous and varied organic remains, indicate that we are here on the junction line of two formations, and that the "Tea-green Marls" belong to the Keuper and not to the Rhætic series, and that they cannot properly even be looked upon as "passage-beds" from one to the other. The authors who first determined the presence of Rhætic rocks in England—Mr. Charles Moore* and Dr. Thomas Wright†—took this view, and drew the line between the Rhætics and the Trias at the base of the *Avicula contorta* shales. In his original description of the section at Garden Cliff, Westbury-on-Severn, in 1865, Mr. Etheridge placed the "Tea-green Marls" in the Rhætic series,‡ but in 1871 he appears to have been in some doubt on the subject, for in a paper given by him to the Cardiff Naturalists' Society in that year, we find in the generalized table at the end that the "Tea-green Marls" are classed with the Keuper, whilst in another part of the same paper, and in the sections there given of Garden Cliff, Westbury, and Penarth Cliffs, they are included in the Rhætic series.§ As I have already stated, the Geological Survey authorities have been in the habit of classing these "Tea-green Marls" with the overlying black "Paper Shales," and also, I may add, with the true "White Lias," under the common term, "Penarth or Rhætic Beds." ‖ That is to say, beds which in my view

* *Quart. Journ. Geol. Soc.*, vol. xvii. p. 483.

† *Quart. Journ. Geol. Soc.*, vol. xvi. p. 374.

‡ *Proc. Cotteswold Naturalists' Field Club*, vol. iii. (1865) p. 218.

§ *Trans. Cardiff Naturalists' Society*, vol. iii., pt. ii. (1870–71) pp. 39, 59.

‖ Mem. Geol. Surv., *Geology of East Somerset and the Bristol Coal-fields*, p. 69.

belong to three distinct formations, Keuper, Rhætic, and Lias, are by these authorities included in one of them, viz., the Rhætic. In his excellent *Geology of England and Wales*,* my friend, Mr. Horace B. Woodward, defends this course partly on the ground that it had been found most practicable, on the maps of the Geological Survey, to draw the boundary line between the Rhætic and the Keuper at the base of the "Grey Marls," and partly because in certain sections, such as those near Axmouth and Watchet, there are appearances of a transition from the "Grey Marls" into the overlying *Avicula contorta* shales. Following Moore and Wright, I have always myself taken the opposite view on this question. In a paper on the Rhætics of Nottinghamshire, read before the Geological Society in the year 1882,† I gave expression to that view in the following words: "I cannot admit that the green marls, which in this (Notts) and the adjoining districts come below the *Avicula contorta* shales, belong to the Rhætic series. For whilst there is always a sharp stratigraphical line of division, with in some cases evidences of erosion, between the 'Tea-green Marls' and the black 'Paper Shales' of the *Avicula contorta* series, there is, on the other hand, every appearance of a gradation between the 'Tea-green Marls' and the underlying red and green marls of the Upper Keuper formation. Again, whilst there does not appear to be any essential difference in textural character between the green marls which come at the top of the Upper Keuper and those lower down in that series, there is a very decided textural distinction between the green marls and the overlying Rhætic shales. The 'Tea-green Marls' are, like the rest of the Keuper rocks, practically unfossil-

* 2nd edition, 1887, p. 245, and see also discussion on my paper on the Pylle Hill section, *Q. J. G. S.*, vol. xlvii. p. 545.

† *Quart. Journ. Geol. Soc.*, vol. xxxviii. p. 451.

iferous, whereas with the very commencement of the *Avicula contorta* shales we get evidence of the incoming of a decidedly marine fauna, including not only forms of life that characterize the Rhætic formation of Europe, but also *species* of mollusca and reptilia which range into the overlying Liassic strata. For these reasons, then, I am of opinion that in Notts and the adjacent counties at any rate, the line between the Rhætics and the Trias should be drawn at the base, not of the green marls, but of the *Avicula contorta* beds." And again: "Probably in both districts" (*i.e.*, in Notts and the West of England) "these green marls were once red in colour" (as is evidenced by the occasional presence in them of red blotches) "and non-calcareous, and have since become bleached and calcareous in part by the downward infiltration into them of some deoxidizing chemical agent and carbonate of lime, derived from the decomposition of the abundant organic remains of the overlying *Avicula contorta* shales. The very general occurrence of 20 feet or so of 'greenish marls' at the top of the Keuper Marls in this country is a coincidental result of discoloration. Neither the textural characters, the stratigraphical relations, nor the organic remains of these beds, justify us in separating them from the rest of the Keuper formation and classing them as Rhætic." * In my later paper on the Pylle Hill section, I observed also on the difficulty there was in supposing these "Tea-green Marls" could be a "passage-series" from Keuper to Rhætic, owing to the fact that they form a natural capping to the Upper Keuper Marls in different districts, where that series attains very different dimensions and therefore cannot be on the same horizon in all cases. I also noticed the fact, which I would emphasize here, that except for a faint resemblance in colour, the mineral char-

* *Quart. Journ. Geol. Soc.*, vol. xxxviii. p. 451.

acters of the "Tea-green Marls" are not—as Mr. Woodward seems to imagine—similar to, but, on the other hand, are totally different from those of the Upper Rhætic Shales.

I come now to the still more difficult and debatable question, What is the *upper* boundary of the English Rhætics? The precise level where the line should be drawn between the Rhætics and the Lias in the West of England has for some time past been in a state of uncertainty, our leading Rhætic authorities, Moore, Wright, Etheridge, Tawney, Boyd Dawkins, and H. B. Woodward, having taken very different views on this point, as will be seen on reference to the literature of the subject.* At the base of the ordinary or typical beds of blue limestone and shale of the Lower Lias, we generally find, in this part of the country, a thin and variable series of cream-coloured or light grey limestones and shales, which are commonly called "White Lias." This quarryman's term is, however, an unfortunate one, for since it was first adopted by William Smith in the

* *Moore, C.*—"On the Zones of the Lower Lias and the Avicula Contorta Zone." *Quart. Journ. Geol. Soc.*, vol. xvii. p. 483.

Wright, T.—"On the Zone of Avicula Contorta, and the Lower Lias of the South of England." *Quart. Journ. Geol. Soc.*, vol. xvi. p. 374.

Etheridge, R.—"On the Rhætic or Avicula Contorta beds at Garden Cliff, Westbury-upon-Severn." *Proc. Cotteswold Nat. Field Club*, vol. iii. (1865) p. 218. And, "On the Physical Structure and Organic Remains of the Penarth (Rhætic) Beds of Penarth and Lavernock, with a Description of the Westbury-on-Severn Section." *Trans. Cardiff Nat. Soc.*, vol. iii. (1870–71) p. 39.

Tawney, E. B.—"On an Excavation at the Bristol Water Works Pumping Station, Clifton." *Proc. Bristol Nat. Soc.*, n.s. vol. ii. (1878) p. 179.

Dawkins, W. B.—"On the Rhætic Beds and White Lias of Western and Central Somerset, etc." *Quart. Journ. Geol. Soc.*, vol. xx. p. 396.

Woodward, H. B.—Mem. Geol. Survey. "Geology of East Somerset and the Bristol Coal-Fields" (1876) p. 69.

year 1815, it has been applied by different authors to very different things, and in particular to a lower and an upper series of beds, the former of which contain the characteristic Rhætic fossils and are therefore certainly Rhætic, whilst the latter are, for a similar reason, as certainly Lias. In taking these two distinct series together, their fossils have been commingled, and considerable confusion has in consequence arisen. When I gave my paper on the Rhætics of Nottinghamshire,* at which time I was not aware of this double meaning of the term "White Lias," I was betrayed into using it as equivalent with "Upper Rhætic"; but when I came into the Bristol district I very soon found this out, and, in the discussion which followed my paper on the Pylle Hill section, my friend Mr. Winwood entirely misrepresented me when he said, "he was glad to find corroborated Charles Moore's view that the White Lias belonged to the Rhætic formation." On the contrary, according to *my* view of the matter, the term "White Lias" is only properly applicable, if it be a legitimate term at all, to those lowest light-coloured limestones and shales of the Lower Lias—the limestones generally predominating—containing such fossils as *Modiola minima*, *Ostrea liassica*, and *Monotis decussata*, which, if present at all, come beneath the regularly stratified blue Lias limestones of the *Ammonites planorbis* series, and rest upon the light grey shales and limestones of the Upper Rhætic series. The "White Lias," as thus defined, is best developed in, if not limited to, the counties of Somerset, Gloucester, and Dorset. The true White Lias is absent as a distinguishable series from the Liassic districts of the North of England, generally, if not entirely, also from the Midland counties, and apparently also from South Wales. In the immediate neighbourhood of Bristol these beds are

* *loc. cit.*

exceedingly thin, but they are generally well developed in the county of Somerset. They attain a thickness of from 10 to 15 feet in the vicinity of Bath, and in the railway cutting at Weston Station, near that town, they are finely displayed, as was formerly also the underlying "Cotham Marble" in characteristic form. The White Lias limestones are also well exposed in many quarries in the Radstock district, where they are worked for road metal, and also for walling and building purposes.

The "Upper Rhætic" beds, or Rhætic "White Lias," both in the Midland counties and in the West of England, are quite distinct in their lithological characters from the true—or Liassic "White Lias," and contain a very different group of fossils. Typically they consist of thinly laminated light blue shales with bands of light grey or cream-coloured, regularly-bedded or nodular, limestones, at greater or less distances apart, the shales generally predominating. The limestones may be, like the shales, almost entirely destitute of organic remains, as they usually are in the Midlands, or may contain Estheriæ and other fresh- or brackish-water Ostracoda, *e.g.*, Darwinula, in vast numbers, also the remains of small plants Naiadita, probably likewise of fresh-water habit, and, what is most important of all, molluscan and fish remains of the same species as those which are found in the underlying *Avicula contorta* beds, and therefore characteristically Rhætic. In Somersetshire and Gloucestershire the Upper Rhætic beds are generally, but not invariably, capped by that peculiar nodular limestone with dendritic markings, which is known as the "Cotham Marble" or "Landscape Stone," and that bed, therefore, may in this district be generally taken as the upward limit of the Rhætic series.* These beds, then, from the Cotham Marble down to

* This is not always strictly the case. For instance, in the

the top of the black Paper Shales, I take to be an entirely distinct series of beds from that higher series of light-coloured limestones and shales above defined as the true White Lias, and to belong to a different formation, and I have proposed for them the term "Upper Rhætic," a title which seems distinctly preferable to that of "White Lias" as applied to rocks which differ so markedly from other rocks also termed "White Lias," and which in addition are not Lias at all.

Many years ago it was pointed out by Edward Forbes that the peculiar dwarfed and limited molluscan fauna of the "White Lias"—meaning by that term rather the Upper Rhætic beds than the true White Lias—indicated that these beds were deposited under exceptional physical conditions, perhaps in inland seas like the Caspian Sea, which had been cut off from the open ocean, and had at first had its waters freshened in consequence.* As evidence in support of this hypothesis it will be interesting presently to note the character of the organic remains contained in the Upper Rhætic beds of the Pylle Hill section, which in this as in other respects, may be taken to give the typical characters of these rocks as developed in this part of the country.

To return to our detailed description of the Pylle Hill section. In that section I take the three or four feet of light-coloured rubbly limestone and laminated shale (beds *o*, *p*, *q*, *r* of my section) to be the attenuated representative of

Willsbridge section at Bitton, near Bristol, described by Charles Moore in the *Quart. Journ. Geol. Soc.*, vol. xxiii. p. 498, there were found to be four feet of light blue shales with *Estheria minuta*, "*Cythere liassica*" and *Avicula decussata* above the Landscape Stone, and which the Ostracoda show must be classed with the Upper Rhætic.

* *Ramsay, A. C.*—"On the Physical Relations of the New Red Marl, Rhætic Beds and Lower Lias." *Quart. Journ. Geol. Soc.*, vol. xxvii. p. 189.

the true "White Lias." These beds here, and at other places in the neighbourhood, contain, with other fossils, chiefly casts and therefore indeterminable, *Monotis decussata*, *Modolia minima*, *Ostrea liassica*, and *Lima gigantea* (?). As is the rule with the true White Lias, there is an absence of all really characteristic Rhætic forms in these beds, and I class them therefore as Lower Lias. I take the bed "*n*" of my section, which is evidently the local equivalent of the "Cotham Marble," to be the highest distinctive Rhætic rock in the section. The identity of this bed with the Cotham Marble was questioned in the discussion which followed the reading of my paper to the Geological Society, so I may say now that I subsequently detected the characteristic dendritic markings in this bed at Pylle Hill, and that I have traced this stone to Bedminster Down, two miles further west. Here, in a small excavation in a roadside quarry, just past the last of the houses on the Bridgwater road, this bed may be seen, in a thoroughly characteristic form, resting on the same light grey shales and cream-coloured limestones, with ostracoda, which underlie it at Pylle Hill, and overlain by about four feet of similar rubbly "White Lias" and two or three feet of *Ammonites planorbis* beds. In the famous section at Aust Cliff, the position of the Cotham Marble as the topmost bed of the Rhætic is most clearly defined, but it is there directly succeeded by, indeed welded to, Lower Lias limestone of the normal character of beds of the zone of *Ammonites planorbis*, without the intervention of any true White Lias. The close connection of the Cotham Marble with the Upper Rhætics and its non-connection with the true White Lias is thus clearly demonstrated, as also is the conformable sequence of the true White Lias and the Lower Lias.

To conclude, then, our description of the Pylle Hill section. The beds underlying the Cotham Marble (beds "*i*" to "*m*" of my section), which, with the Cotham Marble (bed "*n*")

I term "Upper Rhætic," are certainly Rhætic, because in the pale grey limestone "*i*" we find such characteristic Rhætic fossils as *Cardium rhæticum*, *Pecten Valoniensis*, *Schizodus Ewaldi*, *Acrodus minimus*, *Saurichthys acuminatus*, and *Gyrolepis Alberti*. These beds contain also remains of the fresh water endogen Naiadita, also *Estheria minuta* var. *Brodieana*, and other smaller ostracoda of fresh- or brackish-water habit, which have been identified by Professor T. Rupert Jones, F.R.S., as belonging to the genus Darwinula, and were very recently described by him as *D. liassica* (Brodie).* The presence of *Estheria minuta* var. *Brodieana*, a form which practically repeats that met with in the Upper Keuper Marls, with or without these other fresh-water ostracodans and the fresh-water plants, is a characteristic feature of the Upper Rhætic beds in this country, and would seem to indicate the prevalence of physical conditions during their deposition, of a somewhat different nature to those which prevailed during the deposition of the more purely marine beds of the Lower Rhætic series.† The presence, however, in these beds of the same marine shells as occur in the Lower Rhætic beds, such as *Cardium Rhæticum* and *Pecten Valoniensis*, for instance, indicates that the area in which the Upper Rhætic beds were deposited was not a *purely* fresh-water one, but was either estuarine or liable to occasional incursions of the sea.

Passing downwards, then, in the section, we enter upon the black Paper Shales or *Avicula contorta* beds, or "Lower Rhætic" series, as we may call them. As these beds will be pretty well known to all Bristol geologists, and as ample details are given in the accompanying section, I need say

* "On the Rhætic and some Liassic Ostracoda of Britain." *Quart. Journ. Geol. Soc.*, vol. l. p. 156.

† *Vide* "Monograph of the Fossil Estheriæ," by T. Rupert Jones, *F.G.S.*, *Pal. Soc.* (1862), p. 77.

very little about them here. The beds have a less thickness than that which they usually attain in the West of England, not exceeding 9 ft. 6 in. at Pylle Hill. They have the typical lithological character, and contain the characteristic fossils of the *Avicula contorta* beds in great profusion at certain levels ; there is no "bone-bed" at their base in any way comparable with the well-known "bone-bed" of Aust Cliff, but instead there is at this horizon a thin seam of quartzose grit containing fish-teeth, scales, and fin spines, quartz pebbles and coprolites. The presence of the little ophiurid, *Ophiolepis Damesii* (Wright), in bed "*f*" is worthy of note, and the blue shelly limestone "*g*" near the top of these shales—the only definite and persistent hard bed in the series—has yielded large numbers of small bivalves and univalves in a solid state, and some of these appear to be new to this country, if not to science.

SECTION AT PYLLE HILL (TOTTERDOWN), BRISTOL.

		ft.	in.	
Lower Lias Limestones and Shales.	*v. Soil*, with limestone rubble	2	0	*Am.* (*Œgoceras*) *planorbis*, *Am.* (*Œgoceras*) *torus*, *D'Orb.* = *Johnstoni*, *Sow.*
	t. Limestones and *Shales*, regularly bedded, in alternating seams of from 2″ to 6″	4	5	*Lima gigantea*, *Pholadomya glabra*, etc.
	s. Limestones, regularly bedded in seams of from 2″ to 4″, with laminated shaly partings	1	0	*Ostrea liassica.*
	r. Limestone, light coloured, argillaceous, rubbly . .	1	9	*Lima gigantea* (*?*).
	q. Limestone, ditto, ditto . .	0	6	
	p. Limestone, ditto, with bivalve shells, chiefly as casts	0	9	*Modiola minima*, *Monotis decussata*, *Lima gigantea* (*?*), *Pleuromya* sp.
	o. Shales, brown, arenaceous, finely laminated, with small crushed bivalves .	0	9	*Monotis decussata*

	ft.	in.	
Upper Rhætic Series.			
n. Limestone, compact, light blue, concretionary, with conchoidal fracture and dendritic markings, "Cotham Marble," 2″ to 8″, average thickness . . .	0	3	Small turbinate Gasteropods (indeterminable).
m. Shales, light blue, finely laminated, with thin sandy seams, and two thin bands of compact white limestone in the middle portion of the series	4	11	Ostracoda of small size, similar to those in bed "*i*" (*Darwinula*).
l. Limestone, regularly bedded, light blue, weathering to a pale greenish yellow tinge, regularly laminated and closely jointed .	0	7	*Estheria minuta*, var. *Brodieana*, and a few small Ostracoda (*Darwinula*). *Naiadita*.
k. Shales, thinly laminated, light grey, weathering to a pale greenish yellow tinge, with thin seams of compact argillaceous limestone	0	10	
i. Limestone, argillaceous, light blue, weathering to a pale greenish yellow tinge; a massive bed, but regularly laminated and closely jointed, with numerous small plants and valves of Ostracoda; also bivalve shells and fish-scales and teeth	1	0	*Actæonina* sp., *Schizodus Ewaldi*, *Cardium rhæticum*, *Cardium* sp., *Plicatula intusstriata*, *Pecten valoniensis*, *Acrodus minimus*, *Saurichthys acuminatus*, *Gyrolepis Alberti*, *Naiadita*, *Darwinula*.

		ft.	in.	
Avicula Contorta Shales.	*h. Shales*, black, earthy, imperfectly laminated above, with shell fragments, coprolites, and fish-scales; more regularly laminated below, with bivalve shells retaining the test	0	10	*Avicula contorta, Schizodus Ewaldi, Myacites striato-granulata, Cardium rhæticum, Pecten valoniensis, Ostrea alpina (?), Gyrolepis Alberti.*
	g. Limestone, compact, blue, shelly, in one or two seams, ironstained on surfaces, and rotting away into a soft sandy clay in the middle, along joint planes	0	3	*Pecten valoniensis, Avicula contorta, Plicatula Archiaci, Schizodus Ewaldi, Modiola minima, Natica Oppelii, Actæonina (C.) oviformis, and other Gasteropods, Schizodus concentricus, Lucina Stoppaniana, Serpula constrictor.*
	f. Shales, black, alternately more regularly laminated and more earthy, with occasional pyritic seams, very fossiliferous at various levels, the *Ophiolepis* at 13″ and 20″ below *g.*	2	10	*Avicula contorta, Schizodus Ewaldi, Ostrea (A.) alpina, Cardium* sp., *Myophoria Emmrichi, Gervillia præcursor, Ophiolepis Damesii, Acrodus minimus, Gyrolepis Alberti, Myacites striato-granulata, Anatina Suessi.*
	e. Shales, black, earthy, pyritic, passing down into .	0	3	
	d. Shales, black, rather thickly laminated, clayey, with thin sandy seams, containing bivalves with well-preserved tests, a few scattered coprolites and small reptilian bones	2	0	*Schizodus Ewaldi, Myophoria Emmrichi, Avicula contorta, Ostrea alpina.*
	c. Pyritic Sandstone, laminated, thin, but continuous, $\frac{1}{2}$″ to 2″	0	1	

		ft.	in.	
Lower Rhætic or	*b. Shales*, black, thickly laminated, with thin sandy streaks, passing down into	1	3	*Pleurophorus angulatus*, *Ostrea alpina*, *Cardium rhæticum*, *Avicula contorta*, *Pecten valoniensis*, *Gervillia præcursor*.
	a[1]. *Shales*, black, firm, and regularly laminated, iron-stained along joints, generally unfossiliferous, but with scattered coprolites, and scales of *Gyrolepis*, and near the top the shells of bed *b*, passing down into	1	6	Coprolites, scales of *Gyrolepis*, and a few bivalves at the top.
	a. Shales, black, earthy, non-laminated, at the base a very thin seam and small pockets of pyritic grit, containing fish teeth, scales, and fin-spines, coprolites, and white quartz-pebbles	0	5	*Acrodus minimus*, *Hybodus minor*, *Gyrolepis Alberti*, *Hybodus cloacinus*, *Saurichthys acuminatus*, *Ceratodus* sp.
Upper Keuper.	"*Tea-green Marls*," light greenish-grey marls, more arenaceous towards the top, with the carbonized remains of plants imbedded in a vertical position, graduating down into	9	0	Plant-remains (indeterminable).
	Red Marls, with bands of greenish-grey marl and sandstone at wide intervals, exposed down to the railway-level about . .	40	0	
		77	2	

Reports of Meetings.

GENERAL.

DURING the past session the usual eight meetings have been held, but there are no features of unusual interest to record.

At the meeting held on October 5th, 1893, Mr. Claud Druitt read a paper entitled, "The Tawny Owl and Nuthatch," which was illustrated by stuffed specimens, eggs, etc. Mr. S. H. Swayne exhibited some clusters of fungus, *Agaricus Fumosus*.

On November 1st Mr. W. A. Shenstone read a paper entitled, "Some Recent Experiments on the Formation of Ozone from Oxygen." An account of experiments was entered into, and a quantity of apparatus used in the researches was exhibited and explained. Mr. H. J. Charbonnier exhibited a stuffed starling whose neck feathers were pure white.

At the meeting held on December 7th, Dr. A. J. Harrison read a paper entitled, "A Few Notches on Old Trees." A number of photographs of notable trees were handed round to illustrate his remarks. Mr. W. A. Shenstone exhibited a piece of "bleeding bread," and gave an interesting account of the micrococcus to which the curious phenomenon is due.

The usual exhibition was held on January 11th, 1894. The members who contributed briefly explained their exhibits, and the remainder of the evening was spent in

examining the various objects of interest laid upon the tables.

Mr. H. J. Charbonnier exhibited a smew and a hybrid pheasant. Mr. G. C. Griffiths exhibited a collection of moths (*Sphingidæ*). Mr. C. Jecks exhibited a specimen of Luxulionite and some eucalyptus leaves. Dr. J. A. Norton exhibited a malformation of a fowl's leg and a section of a turbot. Mr. J. F. Perry exhibited some whale's teeth, a mummied cat, flexible sandstone, king crab, etc. Mr. F. W. Stoddart exhibited some type specimens of spiders. Mr. C. H. Walker exhibited three live natterjack toads. Mr. E. Wheeler exhibited some paintings of fungi, and a preserved specimen of an Australian reptile (*Moloch horridus*). Mr. C. K. Rudge exhibited a trachea of a male black velvet scooter.

On February 1st Professor Lloyd Morgan gave an address on "Evolution"; various crystals and microscopic slides were used to illustrate the arguments brought forward.

The meeting of March 1st was occupied by Dr. Arthur Richardson, who delivered a lecture on "The Measurement of Sunlight." Numerous experiments and lantern slides helped to elucidate the subject.

At the meeting held on April 12th, Mr. Geo. Munro Smith gave a demonstration of lantern slides illustrating the microscopic structure of the body. Mr. G. C. Griffiths read a short paper, written by Mr. E. C. Reed of Santiago, on "The Coleopterous Genus (or sub-genus) Ceroglossus." A collection of beetles, lent by Mr. S. Barton, was handed round to illustrate the paper. Dr. G. H. Barker then exhibited a specimen of the caterpillar *Hepialis virescens*.

At the meeting held on May 3rd, which was the thirty-second Annual Meeting, the reports of the Honorary Secretary and the Treasurer's report and Balance Sheet were

read, and the officers for the ensuing season were appointed. Mr. S. H. Swayne read a paper entitled "The *Tragulidæ* or *Chevrotains*." A number of stuffed specimens were exhibited and handed round.

The meetings have all been held at the University College.

W. M. BARCLAY,

Hon Reporting Secretary.

BIOLOGICAL SECTION.

THE botanical field-work of the Section continues to yield satisfactory results, and an unusual number of new plants have been lately discovered within the area of our local Flora. These include *Melilotus parviflora*, *Rubus dumnoniensis*, *R. pyramidalis*, *Kalt.*, *Chenopodium opulifolium*, *Scirpus acicularis*, and *Carex subulata Doel.*; whilst *Alsine tenuifolia* and *Carex acuta* have been found in fresh localities.

JAS. W. WHITE, F.L.S., *Hon. Sec.*

PHYSICAL AND CHEMICAL SECTION.

DURING the session four meetings have been held at University College, an average of 15 members and visitors being present.

The total number of members is 33.

The following communications were made:—

"The Mathematics of Fractional Distillation based on a Plausible Hypothesis."—Prof. Barrel.

"The Distillation of Three Liquids."—Prof. S. Young.

"Bacteriological Methods."—Mr. F. W. Stoddart.

"A Simple Form of Hot-Water Funnel."—Mr. C. R. Beck.

"Curve Tracing with the Compound Pendulum."—Mr. F. Bligh Bond.

"The Conduction of Electricity through Copper Filings."—Mr. D. Rintoul.

"The Purification of Mercury."—Mr. W. A. Shenstone.

"A New Form of Bunsen and Roscoe's Pendulum Actinometer."—Mr. J. Quick.

CHARLES R. BECK, *Hon. Sec.*

ENGINEERING SECTION.

DURING the Session 1893–4 five meetings were held. The following papers were read:—"Surveying in Unexplored Countries: the Johore Survey," by A. Wharton Metcalfe, Assoc. Mem. Inst. C.E.; "Pearson's Patent Drilling Apparatus for Establishing large Branch Connections to Water and Gas Mains whilst charged under Pressure, and for like or Analogous Purposes," by H. W. Pearson, M.I.C.E.

Adjourned discussions occupied two evenings.

An excursion of members and friends took place to Cardiff on Friday, August 18th, 1893. About twenty-five attended.

After viewing Cardiff Castle (interior and exterior) and the new building being erected for the South Wales Institute of Engineers, lunch was taken at the Park Hotel. Thereafter the party was conveyed by special train from the Rhymney Station to the Roath Dock of the Bute Docks Co., where an inspection was made of the many new and interesting appliances designed by Sir W. T. Lewis and others for the shipment of coal.

Thence the party was conveyed to the recently laid out Dowlais-Cardiff Works, where there are, *inter alia*, three blast furnaces, 75 ft. high, turning out 1,300 tons each per week, four powerful blast engines, eight pumps, eight hot-blast stoves, six 25-ton Siemen's steel melting furnaces, and

a hydraulic machine for breaking 600 tons of pig iron per day.

From the Dowlais-Cardiff Works the party was conveyed back to the Rhymney Station.

Return to Bristol was made by the train leaving Cardiff at 6.23.

On Friday, April 6th, at 8 p.m., a visit was paid by members to the Bristol Electric Lighting Station. Mr. Proctor, the engineer in charge, received the party, and an agreeable and instructive evening was spent in examining the machinery, apparatus, and buildings.

NICHOLAS WATTS, A.M.I.C.E.,
Hon. Secretary.

ENTOMOLOGICAL SECTION.

DURING the summer two excursions of the Section took place—one in May to Dursley. The day was most enjoyable, and many captures were made, principally of the usual Dursley species; but one notable capture was made by Mr. Bartlett of an *Agrotis cinerea*, being, as far as known, the second occurrence of this rare species in the West of England. The second excursion was taken in July to Llantrissat. The day proved stormy and rather boisterous, so that the captures were not extensive, but several species hardly known to the Bristol district were taken. The Section was most hospitably entertained by Evan John, Esq., J.P., whose collection was inspected.

At the indoor meetings of the Section a large number of most interesting exhibitions have been made by different members, both of native and exotic species, principally of Coleoptera and Lepidoptera.

GEORGE HARDING, *Hon. Sec.*

GEOLOGICAL SECTION.

THE work done in the Geological Section during the Session has been rather limited. Besides a paper, published in last year's proceedings, an excursion took place on July 1st, 1893, to Hallatrow, Binegar, Shepton Mallet, and Wells. The party left Bristol by the 2.17 train for Hallatrow; thence by breaks the party proceeded to the Paulton quarries, where a peculiarly condensed series of the Lias beds was inspected, and Speriferina Walcotti and other characteristic fossils from the beds obtained.

The party then drove to Binegar, where the Lias beds resting directly on mountain limestone, were well seen.

A quarry near Shepton Mallet for the working of "bastard freestone" was visited; here the Lias assumes a white sugary appearance, resembling the Sutton stone.

Pecten pollux was obtained, and small fragments of chert from the mountain limestone. Tea was partaken of at Shepton Mallet, whence the party drove to Wells, returning by the 8 p.m. train from Wells.

During 1894 the Section has had a valuable paper on the Rhætic beds of Pylle Hill, from Mr. E. Wilson, the Curator of the Bristol Museum.

This paper will be found in the transactions of the Society.

Mr. J. Marshall was to have exhibited a unique collection of Jurassic fossils, but was prevented by illness from attending. Mr. Marshall has kindly promised to contribute a paper on, and exhibit of, Jurassic fossils.

At the above meeting the annual report and accounts were presented and passed, and the officers re-elected.

An excursion to the new reservoir at the head of the St. Catherine's Valley, near Bath, took place on June 9th.

The party, consisting of members of the Section and

friends, numbered twenty-four, and included the President, Mr. A. C. Pass, Prof. Lloyd Morgan, the Hon. Secretary, Prof. F. R. Barrell, the Rev. H. H. Winwood (Bath), Dr. Norman (Bath), etc., etc. The party was met at Bath by Dr. Norman and Rev. H. H. Winwood.

The party drove by break to Hunter's Wish Farm, where the Rag beds of Great Oolite were seen reposing on Fuller's earth at the top of the slope, the Fuller's earth being from 120″ to 150″ thick.

Below this the Inferior Oolite was seen *in situ*, and many fossils such as *Pexten Marshii*, *Rhynconella varians*, and *trigonia* (*sp.*) were found and collected. Below the Inferior Oolite, Midford Sands were found in position.

Not far from this spot, in a small quarry, highly inclined beds of Great Oolite were seen with some Fuller's earth. It was suggested that these had been brought down by a landslip. The bottom of the valley was occupied by Lower Lias, in which *Cardenia Listeri* and *Ammonitis Ravicorbatus* were found.

On the Lias there rest horizontal alluvial beds of peat, with stratified marl, containing curious rounded concretions of calcareous matter. Helix and nuts, much wood, and other organic remains characteristic of the English Lias, were found.

It was suggested that the alluvial beds were formed in a lake ponded back by the material brought down by the landslips before mentioned. Mr. W. H. Winwood kindly conducted the party, for whose benefit he had had several small pits opened out, by which the party were enabled to follow the explanations of the geology of the locality offered by Mr. Winwood. Tea was partaken of at a farmhouse, after which the party returned by break to Bath.

The ancient Church and Manor House at St. Catherine's were visited, and much admired.

The party reached Bristol about nine o'clock, having spent a most enjoyable afternoon, the weather, which was threatening at the start, having remained fine.

A. WHARTON METCALFE, *Hon. Sec.*

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